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DRILL REGULATIONS

FOR

SEP 29 1900

COAST ARTILLERY,

UNITED STATES ARMY.

PREPARED UNDER THE DIRECTION OF

THE MAJOR GENERAL COMMANDING THE ARMY

BY THE

BOARD ON THE REGULATION OF COAST ARTILLERY FIRE:

Brigadier General JOHN I. RODGERS, U. S. Volunteers,
Colonel Fifth Artillery, President,
Captain HENRY L. HARRIS, First Artillery,
Captain WILLIAM H. COFFIN, Fifth Artillery,
First Lieutenant CHARLES F. PARKER, Second Artillery,
Recorder.

WASHINGTON:
Government Printing Office.
1898.

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FIRST LIEUTENANT CHARLES F. PARKER, SECOND ARTILLERY,
Recorder.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

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WAR DEPARTMENT,
WASHINGTON, D. C., *May 20, 1898.*

The Drill Regulations for Coast Artillery, United States Army, prepared by the Board on the Regulation of Coast Artillery Fire, are published for the information and government of the Army.

To insure uniformity throughout the Army, all coast artillery exercises and maneuvers not embraced in this system are prohibited and those herein will be strictly observed.

R. A. ALGER,
Secretary of War.

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PART I.—GUNNERY.

Gunnery is the art and science of operating cannon; the practise of using artillery weapons of any kind.

Practical gunnery and description of guns, carriages, appliances for mechanical maneuvers, etc., should be taught at the gun, but everything connected with the theory of gunnery, as also all subjects which can be best explained indoors, should be taught by an officer, under the most comfortable circumstances to his hearers, models and the blackboard being freely used, and care being exercised to maintain the interest of the men.

Both the theoretical and the practical instruction should be progressive. Battery commanders alone can arrange the details for the accomplishment of this end, each in his own battery.

When at gun drill, all the principal parts of the gun and carriage should be pointed out and named; at instruction indoors, all technical terms, definitions of gunnery, and all words, such as vertical, parallel, elongated, etc., should be explained in the simplest language.

SECTION I.—CANNON, COAST CARRIAGES, AND DEFINITIONS.

CANNON.

(See Plates—Page I.)

Cannon are artillery weapons not carried and fired in the hands, from which projectiles are thrown by the expansive force of the gases.

They are either smooth-bore or rifled. Spherical projectiles are usually fired from the former; oblong projectiles, from the latter.

To obtain greater ballistic efficiency, for a given diameter, than can be had in the spherical form, projectiles are made oblong and cannon are rifled.

Cannon are of three classes:

(1) *Guns,* in which the length of the bore is large in comparison with the caliber.

(2) *Mortars,* in which the length of the bore is small in comparison with the caliber.

(3) *Howitzers,* or those cannon whose relative length and caliber place them between the other two classes.

Cannon of the United States land service are classified, according to their use, into *mountain, field, siege,* and *coast artillery.*

They may also be classified into those in which the powder charge is inclosed in a metallic cartridge case and those using a cartridge bag. The former are subdivided into:

(*a*) *Machine guns,* using fixed ammunition and provided with mechanism for continuous loading and firing. The mechanism may be operated by man power or by the force of recoil.

(*b*) *Rapid-fire guns,* single-barreled breech-loading guns, using metallic-cased ammunition. In the smaller calibers, the projectile is united to the case; in the larger calibers, the projectile is separate.

Cannon are made of a single piece or are built up of two or more pieces.

Built-up cannon are of two general classes:

The first class is composed of steel forgings, in which a tube extends through the length of the bore, with superposed concentric forgings of as great length as can be economically utilized, and of such thickness as may be determined by considerations of economy of construction and of the elastic strength of the component metals.

The second class is constructed on an inner tube with the remainder of the wall composed entirely, or in part, of a rectangular, circular, or ribbon form of wire.

Built-up cannon are designed to utilize, to the best advantage, the elastic qualities of the metal. No portion should be strained beyond its elastic limit either at rest or during firing. As the greatest strain is at the bore, this portion of the wall is compressed, when at rest, up to its elastic limit, and it is extended, when under the stress of the powder gases, nearly or quite up to its elastic limit for extension.

The elastic limit of a metal is that point beyond which, if it be strained, either by extension or compression, permanent deformation will take place. Hence, there is a corresponding limit in each direction. If a metal be strained beyond either limit, permanent deformation will occur, followed by rupture when the ultimate strength is exceeded.

In a cannon made of a single piece of homogeneous steel, in its natural condition, with no initial compression or extension, the metal at the bore can not be stretched, by the expansion of the powder gases, beyond the limit of elasticity for extension without permanent deformation taking place. If, however, the cannon of the same exterior dimensions be made of concentric tubes properly assembled, so that the metal at the surface of the bore is contracted to its elastic limit for compression, this surface will, in firing, stand a corresponding stress necessary to stretch it back to the normal condition of the first cannon, and thereafter, it may be further strained so as to utilize the elastic qualities for extension. Hence, a built-up cannon may be made stronger tangentially than a cannon of the same dimensions composed of a single piece having the same qualities of metal.

The tangential strength of a cannon is the resistance which it offers to being torn apart in a plane parallel to its axis.

Modern cannon, excepting machine guns, are generally of the built-up, forged-steel type. These are composed of an inner tube with superposed jacket and hoops.

The *tube*, ordinarily made in one piece, constitutes the wall of the bore from breech to muzzle.

A *jacket* is a cylindrical forging concentric with and shrunk upon the tube or over the "C" row of hoops; it extends from the breech to a plane beyond the trunnions.

A *hoop* is a cylindrical forging concentric with the tube, superposed upon the tube, jacket, or other hoops. The "*C*" *row* is in contact with the tube from the muzzle to the jacket and, in some of the later constructions, to the breech.

The "*A*" *row* is next to the jacket, extending from the breech to a plane in front of the trunnions; the "*B*" *row* is superposed upon the "A" row, in rear of the trunnions; and the "*D*" *row*, on the "C" row, in front of the trunnions.

The *breech* of the gun is the mass of metal behind the bottom of the bore.

The *face of the breech* is the rear terminal plane perpendicular to the axis of the bore. The rounding surface, connecting the face of the breech with the exterior cylindrical surface, is the *breech fillet.*

The *breech reinforce* is the portion of the body of the cannon in front of the breech and in rear of the trunnion band.

The *trunnion band* is the hoop located at about the center of gravity, by which the connection is made with the carriage.

The *rimbases* are the masses of metal uniting the trunnions with the trunnion band. The end surfaces, planes perpendicular to the axes of the trunnions, are the *faces* of the rimbases.

The *trunnions* are cylinders designed to rest in the bearing surfaces of the carriage, the axes being perpendicular to the axis of the bore, and ordinarily in its plane. They connect the cannon with the carriage and transmit the strain from one to the other. The faces of the trunnions are the end planes perpendicular to the axes of the trunnions.

The *center of gravity* of a cannon is near the intersection of its axis and the axis of the trunnions. The preponderance is the excess of the moment of weight on one side of the trunnions over that on the other side.

The *chase* is the portion in front of the trunnion band.

The *fillets* are mouldings uniting surfaces of different diameters.

The *bore* is the hollow portion in the center of the cannon in front of the breech mechanism. It is composed of the main bore, the powder chamber, and the shot chamber.

The *main bore* is the rifled portion through which the projectile travels.

The *powder chamber* is composed of the main cylindrical part, ordinarily larger than the main bore, and of the front slope, which is a conical surface uniting it with the shot chamber.

The *shot chamber* is the seat of the projectile in front of the powder chamber. In the earlier constructions, it was composed of the cylindrical portion, the short cone at the seat of the forcing band, and the long cone from the bottom of the rifling uniting with the main bore, designed to make the deformation of the rotating band on the projectile gradual. In later constructions, there is only the long cone connected directly with the slope of the powder chamber.

The *length of the bore* is the distance from the face of the obturator head in its seat to the face of the muzzle.

The *muzzle* is the mouth of the bore. The face is the terminating plane, at the muzzle, perpendicular to the axis.

The *travel* of the projectile is the distance from the base of the projectile in its seat to the muzzle of the gun.

The *charge* consists of the powder and the projectile. The *powder charge* is, in all guns excepting machine and rapid-fire guns, inclosed in silk or serge bags, and is separate from the projectile. In guns of greater caliber than 8 inches, it is put up in two or more sections.

Breech mechanism.—With the exception of machine and rapid-fire guns, all cannon in the United States land service have the slotted, or interrupted screw, fermature, consisting of the following parts:

The *screw-box*, a threaded surface cut upon the interior of a bushing ring or in the rear end of the jacket, and slotted to correspond to the threaded portion of the breech-block.

The *breech-block*, a threaded cylindrical metal plug, with alternating segments of 45 or 60 degrees of the thread cut away.

The *obturator*, a device for preventing the escape of the gas about the breech-block, and consisting of a mushroom-head, spindle, gas-check, nuts, and washers.

The *mushroom-head* and *spindle* are of one steel-forging; the head is of the shape its name indicates; it receives the pressure of the powder gas, and, compressing the gas-check, seals the breech end of the chamber.

The *gas-check* is a plastic disk of asbestos and tallow inclosed in a canvas cover and protected, front and rear, by metal cups, and is mounted on the spindle between the mushroom-head and the face of the breech-block.

The *spindle* passes through the axis of the breech-block and its rear end is secured by nuts; washers are used between the nuts and the base of the block.

and the nuts screwed up to prevent the obturator turning independently of the block.

The *vent* is a cylindrical hole through the obturator spindle and head; the front end terminates in the axis of the bore and is protected by a copper bushing; the rear end is threaded to receive the primer.

The power devices are:

(*a*) The *rotating-crank*, consisting of a straight hand piece, a lever-arm, and a stud, upon which is mounted a pinion which engages in a geared segment; all so constructed and assembled as to rotate the block through an arc of 45 or 60 degrees, according to the arc of the threaded sector.

(*b*) The *translating-roller*, a threaded bar rotated by a crank; a stud on the breech-block engages in the thread and constrains the block to move longitudinally as the bar is rotated.

The *console*, or *tray*, is a bracket which supports the breech-block when withdrawn, and in which the translating-roller has its bearing. It is attached by a vertical hinge-pin to the breech-plate.

The *breech-plate* is screwed to, and covers, the face of the breech.

The *loading-tray* is a section of a cylinder made of brass, with guides on its under side to fit a slot in the screw-box, inserted when loading to protect the screw-threads.

The action of the *slotted-screw fermature* is as follows: The breech being closed, release the crank of the rotating lever and turn it in the direction indicated, until it brings up short, and is secured by its catch; this brings the *threaded* sectors of the block opposite the *slotted* sectors of the screw-box.

Turn the crank of the translating-roller, *contra-clockwise*, until it brings up short; the shock frees the console-latch; swing the console to the right until the securing latch engages. The charge is then inserted and the breech closed by *reverse* movements; the primer is then inserted and the gun is ready to be fired.

COAST CARRIAGES.

(See Plates—Pages II to V.)

Coast carriages are classified:

(1) According to the nature of the cover afforded by the emplacement, into:
    (*a*) *Barbette*, where the gun fires over the parapet.
    (*b*) *Casemate*, where the gun fires through a port.
(2) According to the manner of traversing, into:
    (*a*) *Front pintle*, where the axis of rotation is well in front of the center of gravity.
    (*b*) *Center pintle*, where the axis of rotation is approximately through the center of gravity.
(3) According to the area of fire, into:
    (*a*) *Limited fire.*
    (*b*) *All-round fire.*

Barbette carriages are either *disappearing* or *non-disappearing.*

Disappearing carriages are classified into:

(*a*) *Disappearing proper*, where the gun is raised above the parapet for firing, and recoils under cover.

(*b*) *Gun-lift*, where the carriage proper is a simple barbette carriage mounted on a platform which is raised and lowered vertically by power.

Machine and *rapid-fire* guns used in coast defense are mounted:

(*a*) On *moving*, or *traveling*, carriages, called simply gun carriages, consisting of the carriage proper and the limber.

(*b*) On *fixed mountings*, called rapid-fire mounts, which are disappearing or *non-disappearing*, *recoil* or non-recoil.

The carriage consists of the top-carriage, the chassis and racer, the base ring, and the mechanism for elevating, traversing, hoisting the projectiles, and drawing the piece from battery, in the case of the disappearing carriage.

The top-carriage, made of steel, supports the gun and recoils with it, and consists of the side-frames, transoms, and recoil-cylinders.

In the disappearing carriages, the gun-trunnions rest in trunnion beds in the upper ends of the gun-levers; an axle through the center of the levers rests in bearings on the top-carriage and the lower ends of the levers are connected to a steel shaft which carries the counterweight.

For mortars, the top-carriage is called the trunnion-carriage; the recoil-cylinders are attached to the side-frames that support the trunnion-carriage, and the piston rods to the trunnion-carriage.

The return of the gun to battery is effected:

(*a*) By *gravity* in the case of guns on the ordinary carriages; the chassis rails being given a sufficient inclination for this purpose.

(*b*) By *springs*, in the case of mortars.

(*c*) By *counterweights*, in the case of the disappearing carriage.

The chassis and racer are made of several parts secured together by transoms and bolts, or cast in a single piece. Between the top-carriage and the chassis, are forged cylindrical rollers, placed in a live roller frame or in a recess cut in the top of each chassis rail.

Under the rails is the racer, the bottom surface of which is the upper roller path. The pintle-ring is a circular flange on the interior of the racer; the chassis and racer are constructed of cast iron or cast steel; the azimuth circle is of brass and is secured to the racer, traverse circles, or platform; the equalizing pipe is of copper and connects the recoil-cylinders so as to maintain the pressure the same in the two cylinders. In the disappearing carriage, the piston rods pass through both ends of the cylinders.

The *base-ring* is of cast iron and is secured to the platform by bolts; the pintle is a right cylinder rising from the center; the upper surface of the base-ring is the lower roller path, and conical forged-steel rollers, held in place by two distance rings, rest upon it; the pintle-ring fits over the pintle and the upper roller path rests on the conical rollers; the dust-guard, held in place by steel clips, extends around the racer and the roller ring system, and protects the latter. The rear part of the carriage is supported on traversing wheels which rest on traverse circles secured to the platform.

The *elevating gear* consists of the rack attached to the gun, and the hand-wheels, shafts, and gear-wheels, attached to the top carriage and chassis; the elevating gear for the disappearing carriage consists of the arms attached to the breech of the gun by the elevating band and to racks which move in guides on the faces of the chassis, and of the gear-wheels which engage with the racks; the elevation is indicated by a brass circle on one of the large gear-wheels or by a brass band on the rim of a wheel attached to the elevating shaft.

The *traversing gear* consists of the traversing chain which extends around the base-ring and is secured to it; this chain passes over a sprocket-wheel which is attached to the chassis and is operated by gearing, the power being applied to crank-levers; or of a spur-ring attached to the base-ring and the gearing meshing with it, the power being applied to crank-levers.

Shot-hoist, attached to the chassis, consists of a crane, pulleys, and drum; or of a horizontal shaft gearing with a shot-hoist lever, the lever terminating in a three-pronged fork, the upper two prongs being slotted to receive the trunnions of the shot tray, and the third prong supporting the rear of the shot tray.

The *retraction-gear* consists of the pulleys, ropes or chains, and drum, by means of which the gun is drawn down by hand to the loading position—used *with the* disappearing-carriages.

Rack, a bar, or an arc, having teeth that engage with those of a gear-wheel or worm.

Gear-wheel, a wheel with teeth on the periphery to mesh with a rack, worm-ring, or another wheel.

Bevel-wheel, a wheel having teeth cut on a bevel or conical surface called the face; where the inclination of the face is 45 degrees, it is called a miter-wheel.

Spur-wheel, a gear-wheel having radial teeth.

Spur-ring, a ring having radial teeth.

Sprocket-wheel, a toothed wheel to engage the links of a chain.

Pinion, a small gear-wheel.

Worm, a short, threaded portion of a shaft, constituting an endless screw formed to mesh with a gear-wheel.

DEFINITIONS.

The caliber of the gun is the diameter of the bore. In rifled guns, it is measured across the lands.

The axis of the gun is the axis, or central line, of the bore.

The axis of the trunnions is the central line of the trunnions.

The trajectory is the curve described by the center of gravity of the projectile in passing from the muzzle to the first point of impact. It is divided into the ascending and descending branches, the point of division being called the summit.

The range is the horizontal distance from the muzzle of the gun to that point of the descending branch of the trajectory, called the point of fall, which is at the level of the gun. This term is also applied to the distance from the gun to the target, and from the gun to the point where the projectile strikes.

The line of departure is the prolongation of the axis of the gun at the instant the projectile leaves the bore; it is therefore tangent to the trajectory at the muzzle. It is commonly called the line of fire.

The plane of departure, or plane of fire, is the vertical plane passing through the line of departure.

The line of sight is the right line passing through the guiding points of the front and rear sights; with telescopic sights, it is the line of collimation.

The plane of sight is the vertical plane containing the line of sight.

The angle of departure is the angle which the line of departure makes with the horizontal plane.

Elevation is a general term used to denote the inclination given the axis of the gun, in aiming or laying.

Using the sight, it is measured from the line of sight; *i. e.*, set at zero, the line of sight and the axis of the gun are parallel.

Using the quadrant, it is measured from the horizontal; *i. e.*, set at zero, the axis of the level and the axis of the gun are parallel.

It is of importance that a clear distinction should be drawn and maintained, in practise and on reports, between quadrant elevation and sight elevation.

The relation between these angles is expressed by the equation: $Q\,E = S\,E +$, the angular elevation of target taken with its proper sign: angles measured *clockwise* being considered negative, and *contra-clockwise* positive.

Jump is the change in the inclination of the gun, which occurs during the travel of the projectile through the bore, and is measured by the difference between the quadrant elevation and the angle of departure. It varies with the carriage and platform, and with the elevation. It is negative for some mounts, and must be determined by experiment in each case.

The angle of fall is the angle which the tangent to the trajectory, at the point of fall, makes with the horizontal plane. It is often expressed as a slope;—*i. e.*, 1 on 10, .005 on 1, etc.

The angle of incidence is the angle which the tangent to the trajectory, at the point of impact, makes with the normal to the surface at that point.

Muzzle velocity is the velocity of the projectile at the muzzle. It is sometimes called the initial velocity.

Remaining velocity is the velocity at any given point of the trajectory.

Striking velocity is the velocity of the projectile at the point of impact.

Energy of the projectile is the work stored up in the projectile by the expansive force of the gases generated by the explosion of the charge. It is usually expressed in foot tons. The formula for computing it is: $E = \frac{WV^2}{4480g}$, in which W is the weight of the projectile in pounds; V, the velocity in feet per second; and g, a constant expressing the acceleration due to the force of gravity and taken at 32.16 f. s.

Energy is spoken of as muzzle, remaining, or striking energy, according to the point of the trajectory considered.

Deviation is the divergence of the projectile from the plane of departure; it is due to the component of the wind at right angles to that plane, and to drift.

Drift is the deviation of the projectile due to the rifling of the gun and to the ballistic character of the projectile. It is in the direction of the rotation and is constant for a given gun and range.

Danger space is the horizontal distance about the target within which the projectile can not fall without striking the target. When the danger space includes the entire range, it is called a danger range.

Direct fire is from guns at angles of elevation not exceeding 15 degrees.

Indirect fire (or curved fire) is from guns with reduced charges, and from howitzers and mortars, at angles of elevation not exceeding 15 degrees.

High angle fire is when the angle of elevation exceeds 15 degrees.

SECTION II.—LECTURES.

In the following lectures for the instruction of the enlisted men, the instructor should explain fully, in the simplest language and with the aid of the blackboard, all technical terms used in the lecture for that day. Only the outline of the subject-matter is given in this book, as it is contemplated that the instructor will elaborate and go into the minutest details.

FIRST LECTURE.—RIFLING AND THE TWIST OF RIFLING.

The instructor will explain that if sufficient angular velocity of rotation is given to an elongated projectile around its longer axis, it will move in the general direction of that axis, with a greater accuracy of flight, range, and penetrative power than a round projectile of the same weight.

In order to give it the angular velocity required, spiral grooves are cut in the bore of the gun, and a soft metal cup or band attached to the base of the projectile. The cup or band is, by the action of the powder gas, either expanded or compressed and forced into the grooves when the gun is fired, thus communicating the motion of rotation to the projectile.

By a *groove* is understood the spiral cut made in the bore, and by a *land*, the space between two adjacent grooves. Since the first introduction of rifling, the grooves have increased in number and decreased in depth and width, but they are still sources of weakness, as the action of the powder gas tends to erode them at the junction of the lands and grooves.

The number, depth, and width of grooves depend on the rotating device. In our service, the number of grooves in the coast guns is six times the caliber.

By *twist of rifling* is meant the inclination of the groove, at any point, to the axis of the gun. When this inclination is constant, the twist is said to be *uniform;* when it increases gradually from the breech, the twist is said to be *increasing.*

In our service, the rifling of coast guns and mortars is increasing from one turn in 50 calibers at the breech to one turn in 25 calibers at a distance of about 2 calibers from the muzzle, from which point to the muzzle it is uniform. The same is true of the siege guns, mortars, and howitzers, and the later models of the field guns.

The objection to uniform rifling is that, as the projectile starts from its seat and during the first part of its travel in the bore, the pressure of the powder gas rises to its maximum, and the angular velocity is impressed upon the projectile at this time also. Hence, while the gun is subjected to the greatest pressure due to the starting, it is also subjected to the greatest pressure due to the rotation of the projectile.

With an increasing twist, the projectile takes the grooves gradually, and the strain on the gun is less violent; the powder pressures fall off along the bore as the twist gradually increases, till it reaches the final value necessary to impart the desired angular velocity to the projectile. In this case, the pressures are more uniformly distributed along the bore, and the gun strained less at the origin of motion, while the final velocity of rotation is the same.

From a point about two calibers from the muzzle, the twist is made uniform, in order to give increased steadiness to the projectile at the instant of departure from the gun.

Twist is generally expressed in terms of the caliber, viz: One turn in 40 calibers, etc., meaning that the projectile makes one complete turn in passing over a length of the bore equal to 40 calibers, etc.

SECOND LECTURE.—THE PROJECTILE IN THE BORE.

The total energy stored up in powder is about 576 foot tons per pound; *i. e.*, the gases from a pound of powder, expanding to *infinity*, would do about 576 foot tons of work. The gases from a pound of powder expanding to the *volume of the bore* does about 70 foot tons of work, the amount varying with the kind of powder and the relative dimensions of the charge and the bore. The *difference* is the energy that can not be utilized on account of the limited volume of the bore.

Of the 70 foot tons of work done by the pound of powder gas expanding to the volume of the bore, about 83 per cent. is stored up in the projectile as kinetic energy $\left[\frac{MV^2}{2}\right]$; this is called the useful work. The remaining 17 per cent. is used up in:

(*a*) Heating the gun.

(*b*) Driving the products of combustion, and the column of air in front of the projectile.

(*c*) Deforming the rotating band, giving rotation to the projectile, and overcoming friction in the bore.

The ratio of the useful work to the total energy of the powder is called the *coefficient of useful effect*, or *coefficient of efficiency*, and depends both upon the powder and the gun; it varies from about .09 to .14.

The ratio of the *useful* to the *total work* of expansion of the powder gases in the bore is the *factor of effect;* it varies from .8 to .9.

Comparing the gun to an engine, the *coefficient of useful effect* corresponds to the efficiency of engine and boiler combined; and the *factor of effect*, to the efficiency of the engine alone.

Theoretically, the last atom of powder should be converted into gas as the projectile leaves the bore. The more gradually the gas is evolved, the less the strain on the gun, but the greater must be the length of the bore in order that all the charge may be converted into gas before the projectile leaves the bore. These conflicting requirements are adjusted by the powder maker and the gun maker.

THIRD LECTURE.—THE PROJECTILE DURING FLIGHT—THE TRAJECTORY.

The expansive force of the powder gas, the force of gravity, the rifling, and the resistance of the air, control the projectile in its flight; these will be considered separately and in combination.

Under the influence of the expansive force of the powder gas, the projectile would move in a straight line (the continuation of the axis of the bore) with uniform velocity. The additional effect of rifling would be to cause it to rotate around its longer axis.

Under the influence of gravity alone, the projectile would be drawn toward the center of the earth with a uniformly accelerated velocity. The acceleration is 32 feet per second. In vacuo, the projectile would fall 16 feet during the first second, 48 feet during the second second, 80 feet during the third second, etc.

Under the combined action of the expansive force of the powder gas and the force of gravity, the projectile would describe a plane curve called a parabola.

The following is a diagram of it:

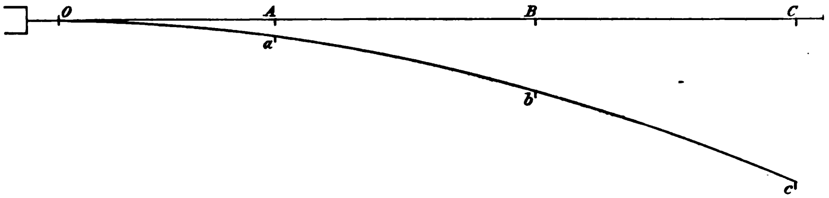

Fig. I.

OA, *AB*, *BC*, distance passed over, in each second, due to expansive force of powder gas.

Aa, *Bb*, *Cc*, distances the projectile falls in one, two, and three seconds, under the influence of gravity.

The resistance which the air offers is proportional to the area opposed and to the square of the velocity, very nearly.

The power of a projectile to overcome the resistance of the air is measured by its ballistic coefficient and is expressed by $C = \frac{\delta_1}{\delta} \cdot \frac{w}{c\,d^2}$; in which δ_1 is the standard density of the air; δ, the density of the air when firing; w, the weight of the projectile in pounds; c, the coefficient of reduction, depending upon the smoothness of the projectile and its steadiness in flight (for standard projectile, $c = 1$); and d, the diameter in inches.

The effect of rifling is explained under the head of Drift.

Under the combined action of the expansive force of the powder gas, the force of gravity, the rifling, and the resistance of the air, the projectile describes a curve of double curvature called the trajectory in air.

The following diagrams illustrate it:

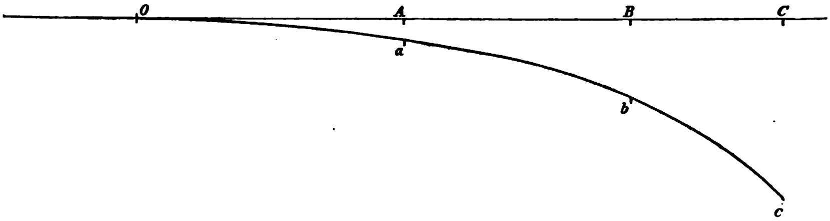

Fig. 2.—Vertical projection.

OA, *AB*, *BC*, are the distances passed over, in each successive second, due to the expansive force of powder gas.

Aa, *Bb*, *Cc*, are distances fallen through in one, two, and three seconds, due to the force of gravity.

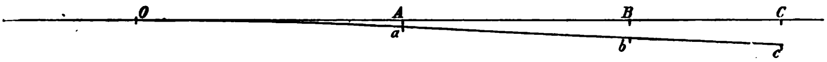

Fig. 3.—Horizontal projection.

Aa, *Bb*, *Cc*, are the drift, right of the plane of fire, at *A*, *B*, and *C*.

Remarks.—Increasing the weight of a projectile, the diameter remaining the same, increases its ballistic efficiency. The weight may be increased by increasing the length or density. Other considerations, however, limit the length, such as steadiness of flight, and strength of walls to resist the force of discharge in the case of shell.

Accurate turning, centering, and smoothness of surface also increase the efficiency of a projectile.

The following examples illustrate some of the advantages of the oblong projectiles:

The 15-inch smooth-bore gun, with 1,700 f. s. muzzle velocity, projectile 450 pounds, has, at a range of 1,000 yards, 1,259 f. s remaining velocity.

The 8-inch breech-loading rifle, 1,700 f. s. muzzle velocity, projectile 290 pounds, has, at a range of 3,600 yards, 1,264 f. s. remaining velocity.

The lighter projectile, at 3.6 times the range, has one-fourth greater striking energy per inch of circumference.

Comparing similar projectiles, the higher the muzzle velocity, the flatter the trajectory. High muzzle velocity and flat trajectory give greater striking energy against vertical targets and greater danger space. Lower muzzle velocity and high trajectory give greater angle of fall and hence greater efficiency against horizontal targets and behind parapets.

FOURTH LECTURE.—CENTERING—CAUSES AFFECTING THE ACCURACY OF FIRE.

A projectile is said to be properly centered when its axis at starting coincides with the initial direction of the motion of translation. When this is not the case, an angle is formed between the two, which, before gravity has had time to act, causes the projectile to revolve about other than its longer axis, thus setting up a gyrating movement, affecting the drift and steadiness of flight; but this generally becomes less sensible as the range increases, and the projectile steadies down in flight from the friction of the air.

Accuracy of fire is said to be good when a group of projectiles, fired under as nearly the same conditions as possible, strike the target close together.

The chief causes of inaccuracy of fire are.

(1) Defects in the construction and assembling of the gun, carriage, and platform, or injuries received from firing or other causes:

(*a*) Instability of the mounting, giving rise to a variable jump.

(*b*) Want of centering in the projectile.

(*c*) Inclination of the trunnions to the horizontal.

(2) Want of uniformity in the ammunition:

(*a*) Variation in the strength of powder. The errors due to the charge can be made as small as possible by using powder of the same make and date, by careful weighing, and by giving uniform density of loading.

(*b*) Variations in the distribution of mass in the projectile.

(3) Errors in laying.

(4) Errors in allowance for force and direction of the wind.

FIFTH LECTURE.—CAUSES AFFECTING VELOCITY AND PRESSURE.

These causes are:

(1) The nature and condition of the powder:

(*a*) The denser the powder, the slower will be the combustion; the harder the powder, the slower will it ignite. Uniformity in the size, shape, and density of the grain, will insure uniformity in the density of loading, which will result in uniform pressures and velocities.

(*b*) A charge composed of large grains will burn more slowly and exert less strain on the gun than one composed of small grains; on the other hand, the larger grains afford larger interstices between them for the flame, thereby facilitating the ignition of the charge.

(*c*) Glazing of gunpowder smooths and hardens the surface of the grains, thus retarding the ignition and making it slower of action.

(*d*) Moisture in powder reduces both the velocity and pressure.

(*e*) The slower the powder burns, the less the pressure, and a proportionally greater charge can be used, giving a greater initial velocity.

In general, an increase in the density, hardness, size of grain, glazing, and quantity of moisture in the manufacture of gunpowder, produces slow-burning powders, which, with equal charges, give less initial velocity than the quick-burning powders, but the pressure in the bore of the gun is so reduced that larger charges, giving greater initial velocity, can be used.

(2) The length of the bore and construction of the gun:

(*a*) The lengthening of the bore, up to a certain point, is rendered necessary by the introduction of slow-burning powders, otherwise all the powder would not be consumed before the projectile leaves the bore.

(*b*) The effect of rifling is to increase the pressure and the initial velocity.

(*c*) *Chambering.*—The diameter of the chamber is made larger than that of the bore, which enables large charges to be made up in tolerably compact forms, thus lessening the abnormal very high local pressure induced by long chambers.

(3) The increase or decrease of the weight of the charge, which, other conditions remaining the same, will increase or diminish the initial velocity and the pressure in the bore.

(4) The density of loading: the smaller the space, the higher will be the initial velocity and the greater the pressure.

SIXTH LECTURE.—RECOIL.

The energy communicated to the gun on discharge is equal to that communicated to the projectile, and must be absorbed in such manner that no injury will result to person or material. The gun is therefore mounted on a top-carriage which is constrained to move, overcoming resistances so adjusted as to reduce and equalize the strains on the mounting.

The distance through which the carriage moves is called the *recoil*, and is measured in the direction of the motion. The recoil is limited to the least practicable distance, taking into account the strength and permissible weight of material that can be used to advantage in the construction.

With a given amount of energy to be absorbed, the shorter the recoil the greater will be the strain on the mounting.

The recoil is controlled by a combination of two or more of the following means:

(1) *Raising a weight.*—In the Buffington-Crozier carriage, the energy of recoil is partly absorbed by raising the counterweight.

(2) *The friction of solids.*—Friction between the top-carriage and chassis.

(3) *The resistance of liquids.*—Recoil-cylinders are attached to the top-carriage and provided with a piston connected with the lower carriage, or the reverse. These cylinders are filled, or partially filled, with neutral oil, which is forced, by the recoil, through apertures in the piston head; or through two ports, or rectangular slots, cut in the rim of the piston head, fitting over throttling bars bolted to the interior, along a rectilinear element of the cylinder, uniformity of resistance being obtained by varying the profile of the throttling bars; or through a by-pass channel, on the exterior, connecting the upper and lower parts of the cylinder.

In the latter case, other holes are drilled at proper intervals connecting the channel with the cylinder, and by-pass plugs are provided to close those holes to such an extent as to make the resistance proportional to the force of recoil. The recoil is absorbed by the resistance which the fluid offers to passage through these holes which are closed successively by the motion of the piston head.

(4) Compression of springs: cylindrical cases containing spiral springs which are compressed by the trunnion carriage when the piece is fired. These springs are principally employed in the new mortar carriages to return the mortar to its firing position, and incidentally take up a small part of the recoil.

SEVENTH LECTURE.—AIMING AND LAYING.

Aiming or laying is the operation of giving the gun the direction and elevation necessary to hit the target. The term *aiming* will be employed when using the sights; and *laying*, when not using the sights.

Instruction will cover the minutest details and will be given systematically, as follows:

A rapid-fire gun, field gun, or barrel of a small arm mounted on a fixed support, and an instruction target, will be used. This target is an ordinary blackboard about four feet square, and a white triangle, with a half-inch hole in the center, attached to a handle about two feet long. A vertex of the triangle will be aimed at and the position marked with chalk through the hole in the center, the triangle being so held that its base is horizontal.

The target should be placed at one hundred yards from the gun or, if this is not practicable, at fifty or twenty-five yards.

CASE I.—Direction and elevation by the sights.

The following points are explained by diagram and with the sights: The principle of the sights, the names and uses of the different parts, the value of the smallest divisions, the adjustments, the guiding points, the line of sight, the axis of the piece, elevation, deflection, the line of departure, and the trajectory.

The operations of giving elevation and direction will be taught separately.

Direction.—The index of the rear sight is placed at zero, the gun aimed, and the position of the triangle marked; the deflection index will then be set at some other reading, and, without moving the gun, the triangle moved to the new line of sight and its position marked; these two marked points should be at a distance apart proportional to the distance to the target and to the number of minutes or points of deflection taken, one minute being equal to very nearly one inch at one hundred yards.

Taking deflection to the right, throws the axis of the piece to the right of the point aimed at, and the reverse.

To determine the personal error in giving direction, have the recruit set the sight at any deflection and aim; direct the position of the triangle to be marked; let the triangle be removed and have the operation repeated, without altering the sight; the horizontal distance apart of the two marks is a measure of the personal error of the recruit. By practise, this error can, where the eyesight is good, be reduced to a minimum.

The triangle may be left fixed and the deflection index moved; the difference between two corresponding readings is the personal error.

Elevation.—The indices are placed at zero and the gun aimed as before; the elevation index is then set at some elevation. The new line of sight will be observed to strike the target at a distance below the triangle proportional to the distance to the target and to the elevation given. Elevate the gun until the line of sight is directed on the triangle; the axis of the gun will then be directed on a point at a distance above the triangle proportional to the distance to the target and to the elevation, one minute of elevation being equivalent to one inch on the vertical target for every hundred yards of range.

To determine the personal error in giving elevation, have the recruit set the sight at any given elevation and aim at the triangle; have the triangle removed and then brought back into the line of sight and its position marked: the vertical distance between the two positions of the triangle is a measure of the personal error of the recruit in giving elevation. By practise, this error can be reduced to a minimum, provided the eye sight is good.

By letting the triangle remain fixed and moving the elevation index, the same test can be made, the difference between two corresponding readings being the personal error.

As soon as satisfactory results have been obtained in the above operations, the recruit will be required to aim the gun, giving both the elevation and direction.

To determine the combined personal error in giving both elevation and direction, have the recruit set the sight at some elevation and deflection, and aim; mark the position of the triangle; the triangle is then removed and replaced as indicated by the recruit and its position again marked; this is repeated, care being taken not to move the gun or sight: the three marked points form a triangle, the dimensions of which indicate the magnitude and direction of the errors.

When sufficient accuracy has been acquired, practise will be conducted for rapidity in aiming.

During these exercises, the following rules should be observed:

(1) See that the indices are set at the proper elevation and deflection, clamped, and not deranged in setting the sight in its seat.

(2) Learn to aim quickly and thus avoid straining the eyes.

(3) Where elevation is given by gear-wheels, aim above and depress to the target, thus avoiding error due to play of gearing.

(4) Choose a clearly defined part of the target and aim at the same point from round to round. Where a ship is the target, aim for elevation at the water line.

(5) Place the eye at the same distance in rear of the sight from round to round.

(6) Make all the corrections on the *scales*, and not by *aiming off* the target.

CASE II.—Giving direction by the sights and elevation by the quadrant or index plate.

The method of instruction is the same as in Case I, and the personal error in giving direction is determined as above. There are no personal errors in giving elevation beyond what may occur in setting the scales and bringing the bubble to the center.

The principle of the rigidity of the trajectory will be explained and its application illustrated by placing the target a known height above or below the gun.

The gun is aimed with a certain elevation which is measured by the sight and by the quadrant, the two elevations compared and their relation explained.

CASE III.—Laying, giving direction by azimuth circle, and elevation by quadrant or index plate.

In this case, the only personal errors are in setting the scales, and the recruit will be practised in setting these until proficient. Points whose azimuths are known will be selected and the recruit required to lay the gun and then verify by looking over the sights.

In Case I, the advantages are:

(*a*) The target is seen when aiming.

(*b*) No corrections are required for height of site, the state of the tide, or for inequalities in the level of the platform.

(*c*) The operation of aiming partially corrects the errors in the estimation of the range, where the gun has considerable height of site and the ranges short.

The disadvantages are:

(*a*) Slowness, in that the two operations of giving elevation and direction must be performed successively and not simultaneously.

(*b*) The difficulty of identifying the water line of the target, especially difficult at long ranges and when the atmosphere is not clear.

(*c*) The effects of refraction.

In Case II, the advantages are:

(*a*) The target is seen while aiming.

(*b*) The operations of giving elevation and direction can be performed simultaneously.

(*c*) Personal errors and errors of refraction in giving elevation are eliminated.

The disadvantages are:

(*a*) Corrections must be applied for height of site, state of tide, and inequalities in level of platform in case index plate is used.

In Case III, the advantages are:

(*a*) The difficulties of fog and smoke are eliminated as far as the gun is concerned.

(*b*) The gunner is not exposed while laying the gun.

The disadvantages are:

(*a*) The target is not seen while laying the gun.

(*b*) The same as in Case II.

MEASURE OF ACCURACY OF FIRING.

If a shot be fired with a certain elevation and direction at a target, the distance of the point of impact from the center of the target is the *deviation from the center of the target.*

The longitudinal and lateral deviations (horizontal target), or the vertical and horizontal deviations (vertical target) from the center of the target, are the co-ordinates of the point of impact referred to that center (see Figs. 4 and 5).

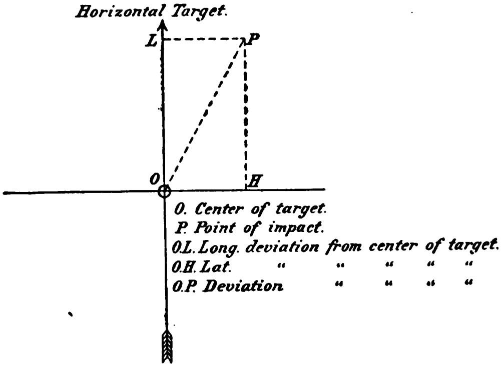

Fig. 4.

A vertical deviation is equal to the corresponding longitudinal deviation multiplied by the tangent of the angle of fall.

The distance of the point of impact from the plane of fire is the *deviation from the plane of fire;* it is expressed in linear or angular measure; in the first case, it is measured on a line through the point of impact and perpendicular to the plane of fire; in the second case, it is the angular distance of the point of impact from the plane of fire.

No definite reliable inference can be deduced from one shot.

If with uniform ammunition, constant atmospheric conditions, and the same elevation and direction, a number of shots be fired from a gun, the several points of impact will be found clustered thickest around a central point called the *center of impact,* the algebraic sum of the deviations (longitudinal, lateral,

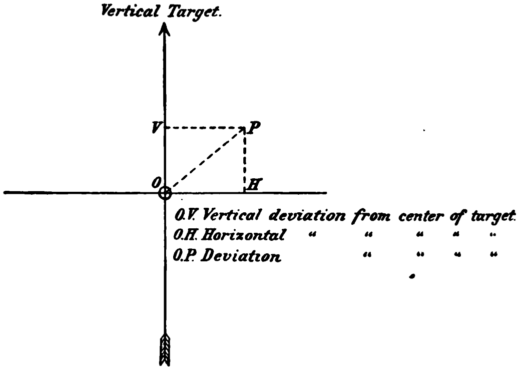
Vertical Target.
V
P
O
H
O.V. Vertical deviation from center of target.
O.H. Horizontal " " " " "
O.P. Deviation " " " "

Fig. 5.

vertical, or horizontal) referred to its center of impact is equal to zero. The distance of any point of impact from this center is the *deviation from the center of impact.* The longitudinal and lateral deviations (horizontal target), or the vertical and horizontal deviations (vertical target) from the center of impact, are the co-ordinates of the point of impact referred to that center (see Figs. 6 and 7).

The arithmetical mean of the longitudinal deviations from the center of impact is the mean longitudinal deviation from that center, etc.

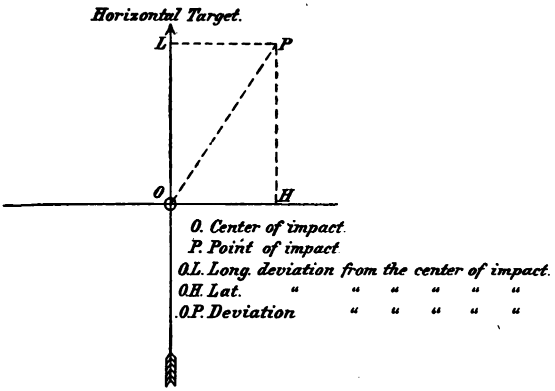

Fig. 6.

If the shots were not fired under uniform conditions, corrections can be applied provided the conditions under which they were fired are known, and the deviations that would have occurred had they been fired under uniform conditions, determined.

If the mean longitudinal, vertical, lateral, and horizontal deviations be multiplied by 1.7, the corresponding zones containing 50 per cent. of the points of impact are obtained; these zones are called the *probable zones.* They are determined at the proving ground; but since they depend on the ammunition and mounting as well as the gun, and since the gun may become injured from service, these probable zones should be determined from time to time for the guns as

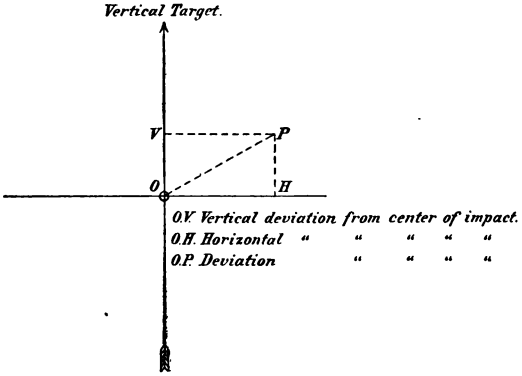
Vertical Target.
V
P
O
H
O.V. Vertical deviation from center of impact.
O.H. Horizontal " " " " "
O.P. Deviation " " " "

Fig. 7.

mounted for service and with the ammunition furnished; the results should be entered in the range tables.

If in any firing, 50 per cent. of the shots are put in the probable zones, no fault can be found even if the target is not hit every time. In other words, these zones are the standards of accuracy for the gun and its ammunition, and having attained that standard in the firing it only remains to place the center of impact on the center of the target and to keep it there.

In the observation and direction of fire and in the analysis of practise, the above principles should be kept in mind—the important thing is not how many *bull's-eyes* are made, but how closely the gun is shooting relative to its service standard, how many shots are required to find the target, how near the center of impact is placed to the center of the target, and where to place the blame for any faults.

PART II.—AMMUNITION.

After explaining the ammunition used for each particular gun and each item forming the charge, the instructor will proceed to show how powder is cared for, stored, and transported; how shot, shell and shrapnel, are recognized, marked, and stored; how cartridges are filled, marked, and stored; how shell are filled and the care to be taken in handling them; the kinds of fuses, their action, and how they are inserted.

MAGAZINES.

Main Magazine:—Building or buildings at suitable places, convenient of access, in which powder in bulk, filled cartridges and shell, etc., may be stored.

Service Magazine:—That portion of each gun emplacement arranged for the ammunition, etc., required for the service of that gun, and consisting of the—

(1) *Cartridge Room,* for the storage of cartridges.
(2) *Shell Room,* for the storage of shell.
(3) *Shot Room,* for the storage of shot.
(4) *Storage Battery Room,* for the storage battery.
(5) *Storeroom,* for tools, repairing materials, etc.
(6) *Ammunition Lifts,* for raising ammunition to the loading platform.
(7) *Relocating Room,* for the battery.
(8) *Stations for the Observation of Fire,* for the battery commander.

Service magazine capacity:—200 rounds of powder, stored in cases, standing on their ends, 3 or 4 tiers high, and served to the lift by hand; 100 rounds of shell and shrapnel, and 100 rounds of armor-piercing shot, stored on their sides, points in, 4 tiers high, and served by overhead trolleys to the lifts or cranes.

Small wheeled trucks carry both powder and projectile from the lifts to the guns.

For the preservation of the powder and of the floors and lining of the *main magazine,* it is of the greatest importance to preserve unobstructed the circulation of air under the flooring as well as above. The magazine should be opened and aired in clear dry weather, when the temperature outside is lower than that inside the magazine. It should not be opened in damp weather if it can be avoided.

The ventilators must be kept free; no shrubbery or trees should be allowed to grow so near as to shade the building from the sun. The magazine yard should be paved and well drained. The moisture of a magazine may be absorbed by chloride of calcium suspended in an open box under the arch, and renewed from time to time; quicklime is dangerous and should not be used.

Before going into a magazine, the instructor will explain the precautions to be taken on entering, working in, and leaving it. Every one who enters a magazine should take off his shoes, or put socks over them; he should have no firearms, no sword or cane, or anything which might occasion sparks. No lights, other than the authorized ones, are allowed in the magazine.

GUNPOWDER.

Gunpowder is a very intimate mixture of potassium nitrate (niter), sulphur, and charcoal, ordinarily in the proportions of:

75 parts of nitre,
15 parts of charcoal,
10 parts of sulphur,

and is classified according to the size of the grain, into musket or rifle, mortar, cannon, and mammoth powder, and into the "special powders"—hexagonal, sphero-hexagonal, and prismatic.

The kinds of powders now adopted for use with service coast cannon are:

Brown prismatic, for the 8, 10, and 12-inch B. L. R. guns and the 12-inch B. L. R. mortars.

Black sphero-hexagonal, for reduced charges with the 12-inch mortars, granulation 96, and for the 15-inch smooth-bore and 8-inch converted rifle, granulation 64.

Black prismatic and *black musket* powders for igniters.

In the brown prismatic powder, manufactured by the Du Pont Powder Company, baked wood, which retains its fibrous structure, and a carbohydrate, such as sugar, are substituted for charcoal and the proportions are:

78.0 parts of nitre,
2.8 to 3 parts of sulphur,
3.0 to 4 parts of carbohydrates,
12.0 to 12.5 parts of baked wood.

The prismatic grain (brown and black) is a right prism one inch high, pierced with an axial hole ⅜ of an inch in diameter, the base a regular hexagon inscribed in a circle 1¾ inches in diameter. The granulation is about 10.33 per pound.

Saluting powder, for saluting, drill, or other purposes: a grade of black powder of about the same composition as ordinary powder, but made of less refined materials and not so long in the mills. It is, however, sufficiently well made to stand transportation and storage, and to be clean in the gun, while it gives a better report than the regular service powder which is intended to be used with a projectile. There are two grades of this powder, differing merely in granulation: one for the field guns and the other for coast smooth-bore guns.

Preservation and storage of gunpowder.—Government powder is packed in metallic barrels containing 100 lbs., or in wooden boxes containing 150 lbs. each.

Powder barrels are made of corrugated iron, with an opening 5 inches in diameter in the head. *Packing boxes*, in which all prismatic powder is now packed, are ordinary pine boxes (18¾" × 18½" × 18¼", interior measurement), lined with tin, and provided with a strip of rubber to make the top fit air-tight.

The barrels are marked on their heads, and the boxes, on one end, as follows: 1, the kind; 2, the piece for which intended; and 3, the lot, distinguished by the factory, the number at the factory, and the year, a separate series of numbers for each kind of powder and piece or group of pieces using the same powder, and a new series beginning with each calendar year, thus: Brown Prismatic Powder for 10-inch B. L. R., U. S. A., Du Pont Lot No. 1, 1896; Black Sphero-Hexagonal Powder for 12-inch Mortars and Siege Cannon, U. S. A., Cal. Pow. Wks. Lot No. 1, 1896; and so on. To distinguish the lot, it is necessary and sufficient to mention the kind, piece, factory, number, and year.

In the main magazines, the barrels and boxes should be placed so that the marks on each can be plainly and readily seen. They are generally arranged three or four tiers high, and, in the case of barrels, small skids are placed on the floor and between the several tiers in order to steady them, and chocks are placed at intervals on the skids to prevent the rolling of the barrels. The barrels should be turned at least once in three months to prevent the powder from caking. This is done by taking down one or two barrels from each row, and rolling the rest back and forth, and then replacing the barrels which have been removed.

The powder should be separated according to its kind, place and date of fabrication.

In moving powder in a magazine, a cloth or carpet should be spread; all instruments used should be of wood or copper, and no repairs should ever be made in the magazine.

Barrels of powder should not be rolled for their transportation, but should be carried in handbarrows or slings made of rope or leather. In wagons, barrels and boxes of powder should be packed in straw and secured in such a manner as not to rub against each other, and the wagon covered with a heavy canvas paulin.

In transportation by railroad, each barrel should be carefully boxed and packed so as to avoid friction. Barrels and boxes should have thick paulins under them and the cars should be provided with springs similar to those of passenger cars.

Storage cases.—These have not yet been definitely settled upon, but will consist essentially of a wooden box, of a size suitable to contain the cartridge or section, lined with tin, a cover held tightly in place by a bar of brass on the top, working on a center pivot, the ends wedging under brass bars which form a part of brass handles which are on two opposite sides of the box. A gasket of rubber is secured to the upper edges in order that the cover may fit air-tight.

These cases are marked on the top with a brief description of the contents, as thus: 67½ lbs. 8-in. B. L. R., etc.

CARTRIDGES FOR COAST CANNON.

Cartridge bags are made either of woolen or silken stuff, which should be soft and closely woven to prevent the powder from sifting through. The seams should be sewed with woolen yarn or silk.

Black Sphero-hexagonal Powder.—In filling cartridge bags with this powder, the charge is first weighed, then carefully introduced into the bag, and settled by shaking until the diameter of the bag is as nearly as possible equal to that of the bore; then the neck of the bag is securely tied. Care should also be exercised in having the length of the cartridges the same.

Each cartridge bag will be stenciled on the side with the quantity, kind of powder, initial velocity, kind of piece for which it is intended, and the lot, thus:

Blk. Sph.-Hex., 35 lbs., I. V. 1,425 f. s.—8-in. M. L. R.
Cal. Pow. Wks. Lot No. 1, 1896.

Brown Prismatic Powder.—The following instructions will be observed in the preparation of cartridges of this powder for service use in coast cannon:

1. The total length of the cartridge for the *guns* should be at least nine-tenths the length of the chamber, in order to avoid irregular and excessive pressures; but this condition need not be fulfilled for the *mortars*. It is to be obtained by a suitable selection of the cross section of the cartridge.

2. The charges for the 8-inch and 10-inch guns should be put up in two equal parts or sections, and those for the 12-inch guns, in four sections. When the

charge for the latter gun does not exceed 4,386 prisms (about 420 pounds), the sections should be equal, but when larger, the forward or cone section, intended to enter the cone of the chamber, should consist of 19 layers of 61 prisms each, except the upper layer, which should have the corner prisms omitted; the other sections should be equal.

3. The following table gives the dimensions of the sections for brown prismatic powder lots of 1896, for full charges and for reduced charges for practise, calculated to give about 1,725 f. s. initial velocity. For other charges, the cross section can be calculated from the length of the section given in the table, and the granulation (number of prisms to the pound) marked on the box.

Cannon.	Length of section. No. of prisms.		Full charge.		Practise charge.	
	Minimum.	Maximum.	Weight.	Prisms in cross section.	Weight.	Prisms in cross section.
			Lbs.		*Lbs.*	
8-inch B. L. R	23	24	135	*31	104	23
10-inch B. L. R	30	31	280	*48	214	37
12-inch B. L. R	18	18	490	76	375	55
12-inch C. I. mortar		14	75	†61		
12-inch steel mortar		19	110	†61		

* When the full section of 31 or 48 prisms is used for the 8-inch or 10-inch gun, the prisms should be omitted from the corners of the 23d and 24th, or 30th and 31st layers respectively.

† These figures are for the equal sections; for the cone sections, see above. Whenever practicable, the corner prisms, or those of three adjacent corners, should be omitted for the mortars, and, further, the section reduced to 48 prisms, to facilitate loading.

4. The bag should fit closely in order to hold the cartridge in shape during handling. The best way to obtain a suitable fit is to make a plait near the side seam of the bag, which is made to fit as closely as practicable. Then, after the powder is in, lace the bag tightly with stout twine, passing it around the plait and seam, which prevents the cloth from tearing.

5. To secure proper ignition of the charge of *brown powder*, it is necessary to use an igniter of *black powder*. The most suitable igniters for service use are believed to be the following: (*a*) Seven black prisms in the center of the bottom layer of each section of the cartridge. In this case, the bag should be cut, to secure certainty of ignition. (*b*) The bottom of the bag is made double, the outside part being of thinner material than that now used for the bags. About 2 ounces of rifle powder for the 8-inch, or 3 ounces for the 10-inch and 12-inch, is spread between these bottoms, more thickly toward the middle, and then they are quilted in about inch squares to retain the powder in place. No igniter need be put in the cone section of the 12-inch cartridge when it is different in form from the others. Saluting powder will do for these igniters.

6. Each cartridge bag should be stenciled on the side with the quantity, kind of powder, kind of piece for which it is intended, and the lot, thus:

Br. Pris., 67½ lbs.—8-in. B. L. R.
Du Pont Lot No. 1, 1896.

When the cone section of a 12-inch charge differs from the other sections, it should be plainly marked on the side and base, "Cone Section," and no other sections should be marked on the base.

DIMENSIONS OF MATERIAL FOR CARTRIDGE BAGS FOR COAST CANNON—MAXIMUM AND MINIMUM CHARGES.

Name of piece.	Length.	Width.	Diameter of bottom.	Seam from edge.	Kind of powder.	Material.	
	Inches.	*Inches.*	*Inches.*	*Inch.*			
8-in. B. L. R	32	25	9.50	1	Br. pris	Raw silk or serge.	Min. charge, 2 sections.
	32	31	11.25	1	Br. pris		Max. charge, 2 sections.
10-in. B. L. R	40	33	12.00	1	Br. pris		Min. charge, 2 sections.
	38	38	13.50	1	Br. pris		Max. charge, 2 sections.
12-in. B. L. R	33	37	13.25	1	Br. pris		Min. charge, 3 sections.
	29	42	14.75	1	Br. pris		Max. charge, 4 sections.*
12-in. B. L. M. (steel)					Br. pris		Min. charge.
	29	39	13.75	1	Br. pris		Max. charge, 1 section.
12-in. B. L. M. (cast iron)					Br. pris		Min. charge.
	23	39	13.75	1	Br. pris		Max. charge, 1 section.
8-in. M. L. R. (converted)					Sph. hex		Min. charge.
	35	24	9.00	1	Sph. hex		Max. charge, 1 section.
15-in. M. L. smooth-bore					Sph. hex		Min. charge.
	42	44	†	1	Sph. hex		Max. charge, 1 section.

*Cone section, 29 inches long, 39 inches wide; 13.75 inches diameter of bottom; 1 seam.

† End of bag rounded to an 11-inch radius and sewed up as sketched, thus:

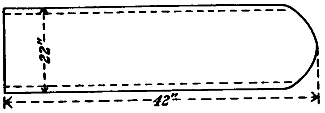

Fig. 8.

PROJECTILES.

(See Plates—Page VI.)

Projectiles may be classified according to their structure as solid shot, shell, shrapnel, and canister; and according to their use, into field, siege, and coast projectiles.

All projectiles used in the United States service, except canister, have practically the same form—a cylindrical body with a pointed head. The length of projectiles varies from 3 to nearly 4 calibers. The curve of the head is the arc of a circle, tangent to the corresponding element of the cylindrical body, and described with a radius of from 1½ to 2 calibers. Rotation is given by a compressible band of copper, slightly larger than the bore, near the base of the projectile.

Solid shot.—For attacking armor, the projectile must possess great hardness to penetrate and great toughness to resist breaking up on impact. If the shot is made solid, it is subjected to initial strains, due to casting or forging, which can not be removed; the metal in the interior is not sound, and hence we have weaker projectiles when solid than when they have an interior cavity or core. This cavity removes the unsound metal, if the projectile is of cast iron, or if of steel, allows it to be treated so that the strains can be removed and toughness attained.

Such shot are generally called "cored shot." They are made of chilled cast iron (Palliser) and of forged or cast steel.

For the B. L. R. guns, a solid shot of cast iron and a cored shot of forged steel have been adopted.

Shell. A shell is a hollow projectile, containing a bursting charge of gunpowder or some high explosive, and a fuse to ignite this charge at some point of its flight or upon impact.

Shells are used in the coast, siege, and field services, and their construction depends on the purpose for which they are intended, classifying them into *common*, *armor-piercing*, *torpedo*, and *deck-piercing*. These differ from each other principally in the size of the cavity for the bursting charge.

For the B. L. R. guns, armor piercing shells of steel have been adopted; and for the B. L. R. mortars, deck-piercing shell of steel, torpedo shell of forged steel, and shell of cast iron.

All of these shell are designed to contain some high explosive for a bursting charge, but the kind to be employed has not yet been determined upon. Until this question is settled, rifle powder will be used for filling the shell.

Shot and shell are packed separately in wooden boxes provided with rope handles for convenience in handling. These boxes, properly marked on the exterior, are stored in the general magazine, being removed from the boxes only as they are needed for service, the shell being unfilled and the fuse hole being stopped with tow or cotton waste.

Before being taken to the *shell room* in the *service magazine*, the shell are filled and the fuse hole stopped up as before. The fuse is inserted only as each shell is required for use.

The cavity of all shell must be thoroughly cleaned and all greasy matter removed by solvents and then carefully dried before filling. If the bursting charge is of powder, the cavity of the shell must be washed with a lacquer composed of rosin, Spanish brown or metallic red, plaster of Paris, and spirits of turpentine, in proper proportions.

Shrapnel consists essentially of a case or envelope containing small round projectiles, a bursting charge, and a fuse. The charge is sufficient to rupture the envelope, the fuse being arranged to ignite the charge at a given point of flight of the projectile. After rupture of the envelope, the contained projectiles move on with a velocity which is the resultant of that due to discharge and to the bursting charge.

When rupture of the envelope occurs, each contained particle describes its own path, and the paths thus described, taken together, form the elements of the *cone of dispersion.*

To give sufficient strength of wall to withstand the shock of discharge, the body of shrapnel is made of solid forged steel, machined inside and slotted with weakening grooves, with a forged-steel head and base welded on by electricity; or of drawn-steel or wrought-iron tubing, the head and base being made of cast iron screwed into the body.

The bursting charge is placed either in the front or rear part of the projectile, each position having advantages and disadvantages, the better of the two not having yet been determined.

No shrapnel have yet been adopted for the high-powered guns, but the illustrations given on Page VII, Plates, show the general construction of this class of projectiles.

Canister consist of a number of spherical bullets of cast iron, or of lead hardened with antimony, contained in a case made of malleable cast iron, weakened by spiral cuts so as to insure its breaking up in the gun by the shock of the charge. They are little used at the present day, and then only in field guns.

COLORS OF PROJECTILES.

Certain distinctive colors for projectiles have been adopted, so that their nature may be known at a glance. The projectiles, except band and fuses, are coated with a thin, hard, smooth paint, colored as shown in the drawing. (Plates—Page VII.)

FUSES.

(See Plates—Page VII.,

Fuses are the means employed to ignite the bursting charges of hollow projectiles at any point of their flight or upon impact.

They may be classified with reference to their location in the projectile as *base* and *point* fuses: or with reference to their mode of operation as *percussion, time*, and *combination* fuses, according as they are made to explode the charge by the effect of impact, by the burning of a certain composition for a specific time, or contain both of these means of ignition.

Base fuses are inserted in the center of the base of the projectile. They are used with armor-piercing projectiles and generally where penetration is required, and where the head of the projectile must have great resistance.

Point fuses are inserted in the head of the projectile at the point of the ogive and are used, generally, when penetration is not required.

The requisites of a percussion fuse are that it shall be safe in transportation and handling, and certain in its operation—of a time fuse, that its rate of burning should be uniform, that it should not be affected by storage or changes of climate, and that it must be safe in transportation and handling, and certain in its operation; of a combination fuse, that it must combine the requisites of both percussion and time fuses, without being too bulky or too expensive.

Percussion fuses consist generally of a metallic body turned to the proper size and threaded on the exterior for screwing into the projectile. The interior, after being bored out for a plunger, is threaded for a closing-cap screw device which holds the plunger in position. This closing-cap screw device has a receptacle for a primer and is threaded on the interior for the primer-closing screw which holds the primer in place and has a vent that admits the flame from the primer to the shell. The plunger, which before firing is held in position by some device, is freed by the force of discharge or upon impact, and when the projectile strikes, it is thrown forward, the point of the firing pin (one of the parts of the plunger) strikes and explodes the fulminate contained in the primer, the flame of which passes through certain vents into the interior of the shell, igniting the bursting charge.

The time fuse consists essentially of a case of some suitable material, enclosing a column of burning composition which is set on fire by the discharge of the piece or by some mechanical device, and, after burning a certain time communicates with the bursting charge.

NOMENCLATURE, ETC.

Frankford Arsenal, Base Percussion Fuse "A," for Siege and Coast Guns (Figs. 31, 32, and 33).

Model 1893.

Body	*a*	Igniter plunger spindle:	
Closing-cap screw	*b*	Stem	h_1
Primer-closing screw	*c*	Thimble	h_2
Primer	*d*	Firing pin	*i*
Tin-foil disk	*e*	Safety ring	*j*
Primer shield	*f*	Catch pin	*k*
Igniter plunger sleeve	*g*	Powder chamber closing disk	*l*
Composition charge	*m*	Charge of rifle powder	*n*

Model 1894.

The same as for Model 1893, except that the catch pin and spiral spring for uniting the plunger sleeve and spindle when the fuse is *armed* are omitted.

In this fuse, the same purpose is effected by the lodgement of the spring ring in the shallow groove near the bottom of the spindle.

The Model 1893 is shown in cross section, Fig. 31, and in outside dimensions, Fig. 32. (Plates—Page VII.)

The Model 1894 is shown in Figs. 32 and 33. (Plates—Page VII.)

The fuse is made principally from hard-rolled brass rods.

The body has a beveled flange thinned down on the edges to make a gas-tight joint on the base of the shell. It also has a flat on the top for a wrench.

The outside of the body is threaded and turned to the proper size, and the interior, after being bored out for the plunger, is threaded for the closing-cap screw, which holds the plunger in position.

The closing-cap screw has a receptacle for the primer, and is threaded on the interior for the primer-closing screw. The primer-closing screw holds the primer in place and has a vent which admits the flame from the primer to the charge of rifle powder and thence to the shell.

The primer, of sheet metal, has two vents, through which and the vent in the primer-closing screw, the flame from the composition may pass to the charge of rifle powder, and thence to the bursting charge of the shell.

The composition in the primer consists of a mixture of 40 parts of fulminate of mercury, 20 parts of potassium chlorate, 15 parts of sulphide of antimony, and 50 parts of glass. The whole is then incorporated with such an amount of gummy substance as will give the desired consistency to the mass.

The plunger consists of the sleeve, spindle, firing pin, safety ring, catch pin, and spiral spring. The spindle carries the firing pin, which is squared at its point. A recess and groove are cut into the spindle. The recess contains a spiral spring and a catch pin, and the sleeve has an interior groove for the point of the catch pin to enter. The open-spring safety ring is sprung into the groove of the spindle.

To assemble the fuse, the plunger sleeve is slipped over the spindle until it rests on the safety ring, the catch pin being forced into its recess against action of the spiral spring. The plunger complete is now inserted in the body and secured in place by the cap screw.

The primer shield is first placed in the recess in the cap screw, the primer is then inserted, and secured by the primer-closing screw.

The action of the fuse is as follows:

When the piece is discharged, the inertia of the plunger sleeve causes it to slide to the rear against the resistance of the safety ring. This ring is pushed from its seat to the bottom of the spindle. When the plunger sleeve reaches its farthest position to the rear, the catch pin, actuated by the spiral spring, engages in the annular groove in the plunger sleeve, binding the sleeve to the spindle and increasing the mass and, therefore, the effectiveness of the spindle as a plunger. The point of the firing pin now projects beyond the plunger sleeve, and the fuse is said to be *armed*.

On impact, the inertia of the plunger carries it forward, and the point of the firing pin pierces the primer shield and ignites the composition. The flame from the composition passes through the two vents in the primer, through the vent in the primer-closing screw, thence to the charge of rifle powder, and thence to the bursting charge of the shell.

The weight of the sleeve and the resistance in pounds of the safety ring must be adjusted to the velocity at which the fuse is required to act. At the same time the fuse must be safe for transportation.

TRANSPORTATION.

These fuses are packed in tin water-proof cases, in wooden boxes for separate transportation, to be inserted in the projectiles at or near the firing ground. The projectiles may be carried with their bursting charges held by the blank screw plug, which is removed for inserting the fuse. When the projectiles are filled, the threads of the plug are red-leaded to exclude moisture.

The fuse, when assembled, must be screwed tight home to prevent premature explosion from the inflamed gases in the gun.

The fuse is wrapped in tow and inclosed in a cylindrical tin box, the joint of the lid of which is covered by strong paper made water-proof by a coat of shellac. The exterior of the box is bronzed or lacquered to provide a surface to which the glued paper will adhere. A string placed beneath the paper seal enables it to be torn to open the box.

The wooden packing case is designed to be continued in use until all the fuses have been expended. It contains 25 fuses in the tin boxes. Each box has a separate compartment, so that one or any number of fuses may be removed without disturbing the remainder. As the wooden case will ordinarily be carried with the lid uppermost, the packing of the fuses is also designed to have the axis of the fuse in a horizontal position, and thus subject it to the least disturbance in transportation. The top of the box is a sliding lid, battened at the ends to prevent splitting or warping, and fastened by an iron pin which passes through the lid into one end of the box. A brass-wire loop is attached to the handle of the fastening pin and sealed. To open the case, the seal is broken and the handle turned to the right about 90°. This starts the pin, which can then be readily removed.

An illustration of the packing case is shown in Plates—Page VII.

PART III.

MATERIAL.

UNITED STATES COAST CANNON, 1898.

Weights, dimensions, etc.	Breech-loading guns.					Breech-loading mortars.		Muzzle-loading guns.	
	8-inch rifle, steel, model 1888, M.	10-inch rifle, steel, model 1888, M.	12-inch rifle, steel, model 1888, M.	12-inch rifle, steel, model 1892.	16-inch rifle, steel, model 1892.	12-inch cast-iron hooped with steel.	12-inch steel, M. 1890.	8-inch converted, cast-iron, steel tube rifle.	15-inch cast-iron, smoothbore.
Weight ... pounds	32,218	67,783	117,127	128,719	282,240	31,920	------------	15,960	49,000
Weight ... tons	14.5	30.0	52.0	57.5	126	14.25	12.9	7	21.8
Total length ... feet	23.21	30.60	36.66	40.0	49.17	10.75	11.76	11.4	15.83
Length of bore ... calibers	32.0	34.0	34.0	37.83	35.0	9.0	10.0	14.6	11
Maximum diameter of breech ... inches	30.0	38.5	46.2	46.4	60.0	41.75	38.0	32	48
Diameter of muzzle ... inches	14.0	16.8	20.2	19.8	28.0	22.5	21.0	16.2	25
Diameter of trunnions ... inches	10.0	12.0	14.5	14.5	------------	12.0	12.0	------------	------------
Distance between rimbases ... inches	32.5	42.0	50.2	50.2	------------	44.0	40.0	------------	------------
Distance of axis of trunnions from muzzle ... inches	183.0	243.05	291.1	318.0	396.0	79.1	89.6	------------	------------
Rifling:									
Number of grooves	48	60	72	72	96	68	72	24	------------
Width of grooves ... inches	0.3736	0.3736	0.3736	0.3736	0.3736	0.379	0.3736	------------	------------
Depth of grooves ... inches	0.06	0.06	0.06	0.06	0.07	0.07	0.06	------------	------------
Width of lands ... inches	0.150	0.150	0.150	0.150	0.150	0.175	0.150	------------	------------
Twist of rifling ... calibers	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 50 to 1 in 25	1 in 40 to 1 in 25	1 in 40 to 1 in 20	1 in 45	------------
Powder chamber:									
Diameter ... inches	9.5	11.8	14.2	14.5	18.8	12.4	12.5	8	------------
Length ... inches	51.00	65.49	77.68	78.58	106.5	16.05	21.13	20.7 22.0	------------
Capacity ... cubic inches	3,617	7,120	12,183	12,798	29,190	2,021	2,665	969.9 1038.0	------------
Total capacity of bore ... cubic inches	14,109	29,003	50,013	55,829	121,356	12,598	14,001	5,826	28,567
Powder charge—Kind of powder	Brown Pris. Smokeless.	Brown Pris. Smokeless.	Brown Pris. Smokeless.	Brown Pris. Smokeless.	Brown Pris. Smokeless.	Brown Pris. Smokeless.	Brown Pris. Smokeless.	Sphero-hexagonal.	Sphero-hexagonal.

Powder charge:									
Weight of charge ....pounds..	135 [1] 104	280 [1] 214	490 [1] 375	487	1,060	75	110	35	[2] 130 [3] 100
Density of loading	1.03885	1.018488	1.11004	1.0535	1.0000	1.04325	1.1026	1.0000 0.9340	[2] 0.5000 [3] 0.5200
Projectile:									
Weight of projectile (filled) ....pounds..	300	575	1,000	1,000	2,370	[4] 800 1,000	[4] 800 1,000	180 157	[2] 450 [3] 345
Ratio of weight to weight of piece	$\frac{1}{107}$	$\frac{1}{118}$	$\frac{1}{117}$	$\frac{1}{129}$	$\frac{1}{118}$	[5] $\frac{1}{40}$	[5] $\frac{1}{36}$	$\frac{1}{88}$	$\frac{1}{109}$
Weight of bursting charge ....pounds..	....	....	....	....	....	....	....	7	15
Length of projectile ....calibers..	3.5 4.5	3.5 4.5	3.5 4.5	3.5 4.5	3.5 4.5	3.0 3.8	3.0 3.8	....	....
Sectional density $\frac{W}{d^2}$	4.6875	5.7500	6.9445	6.9445	9.2578	[5] 5.5556	[5] 5.5556	2.8125	2.03512
Travel of projectile in bore ....calibers..	25.66	27.51	27.59	31.29	28.37	7.64	8.243	....	....
Muzzle velocity ....f. s..	[8] 2,250 2,025 [1] 1,725	[8] 2,250 2,025 [1] 1,725	[8] 2,250 2,025 [1] 1,725	[8] 2,250 2,100 [1] 1,725	[8] 2,250 2,025	[5] 1,020	[5] 1,150	1,414 shot. 1,475 shell.	1,680 shell. 1,706 shot.
Pressure per square inch in powder chamber ....pounds..	[8] 35,000 38,000	[8] 35,000 38,000	[8] 35,000 38,000	[8] 35,000 38,000	[8] 35,000 38,000	27,500	31,000	....	[2] 28,000 [3] 18,800
Muzzle energy ....foot tons..	8,528	16,345	28,426	30,570	72,300	5,769.7	7,334	....	....
Penetration in steel at—									
Muzzle ....inches..	16.8	21.1	25.8	27.1	36.9	[5] 8.2	[5] 9.8	....	....
1,000 yards ....inches..	15.0	19.2	23.8	25.1	34.8	....	....	5.6	[7] 8.2
2,500 yards ....inches..	12.6	16.6	21.2	22.3	31.8	....	....	4.4	[7] 6.2
3,500 yards ....inches..	11.4	15.1	19.5	20.6	30.0	....	....	4.0	[7] 5.4
Forgings:									
Total weight ....pounds..	39,674	82,472	140,556	152,860	336,000	[6] 36,220	34,595	....	....
Weight of tube ....pounds..	9,632	18,945	32,490	36,054	....	21,178	7,666	....	....
Weight of jacket ....pounds..	9,712	18,115	31,249	34,374	....	....	9,840	....	....
Range:									
Mounted on carriage, elevation in degrees	18	15	....	....	....	45	45	8	8 11
Mounted on carriage, miles	6.8	6.6	....	....	....	5.2	5.2	2	2
Extreme limit ....miles..	10.6	11.7	....	....	....	5.2	5.2	2.3	2.3

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[1] Practise charge.
[2] Solid shot.
[3] Shell.

[4] The 1,000-pound 12-inch mortar shell may be used for ranges up to 2½ miles, with reduced charges; the 800-pound shell will be used for greater ranges and the maximum charge.

[5] For 800-pound shell.
[6] Including cast-iron body.

[7] Unbacked wrought iron.
[8] Smokeless powder.

PROJECTILES, FUSES, ETC., FOR UNITED STATES GUNS AND MORTARS.

Caliber and model.	Material.	Projectiles.			Fuses.	Penetration in steel.			Remarks.
		Kind.	Weights.	Bursting charge.		1,000 yards.	2,500 yards.	3,500 yards.	
			Pounds.	*Pounds.*		*Inches.*	*Inches.*	*Inches.*	
8-inch B. L. R., 1888.	Steel	Solid shot, cast iron Cored shot, cast iron A. P. shot, steel A. P. shell, steel	300			14.2	11.9	10.6	
10-inch B. L. R., 1888.	Steel	Same classification as above	575			18.5	16.0	14.6	
12-inch B. L. R., 1888, 1892.	Steel	Same classification as above	1,000			23.0 25.1	20.4 22.3	18.7 20.6	1888. 1892.
16-inch B. L. R., 1892.	Steel		2,370			31.9	29.2	27.5	
8-inch M. L. R.	Body, cast iron; tube, steel.	Cored shot	180			5.6	4.4	4.0	
		Shell	150	7.0					
15-inch S. B.	Cast iron	Solid shot	450						
		Shell	330	15.0					
12-inch B. L. M.	Cast iron, hooped steel.	D. P. shell, steel	800 1,000	20.8 37.5		8.2			800-pound shell, cast-iron mortar.
		Torpedo shell, steel	800 1,000						
12-inch B. L. M.	Steel	Cast-iron shell	800 1,000			9.7			800-pound shell, steel mortar.

COAST CARRIAGES.

Gun.	Kind.	Model.	Top carriage.			Elevation.	Depression.	Chassis and racer.			Base ring.		Remarks.
			Material.	Weight.	Recoil.			Material.	Weight.	Means of traversing.	Material.	Weight.	
				Pounds.		°	°		*Pounds.*			*Pounds.*	
8-inch B. L. R.	Barbette		Cast steel	6,620	Hydraulic cylinders; 18 gallons neutral oil.	18	7	Cast iron	19,000	Traversing chain and gearing.	Cast iron	19,850	
	Disappearing, L. F	1894	Gun iron		Hydraulic cylinders; 22 gallons neutral oil; counterweights.	12	5	Cast steel		Same as barbette	Gun iron	7,515	
	do	1896	do		Same as 1894 model					Spur ring attached to base ring, and gearing.		10,358	Gun levers, axle, and crosshead, 8,000 pounds.
	Disappearing, A. R. F	1896	do		do					Same as L. F			
	Casemate	1894								Same as barbette			
10-inch B. L. R.	Barbette			9,875	Hydraulic cylinders; 36 gallons neutral oil.				25,185	Traversing chain and gearing.		26,680	Platform, crane, etc., 15,260 pounds.
	Disappearing, L. F	1894	Gun iron	11,935	Hydraulic cylinders; 44 gallons neutral oil; counterweights.	12	5	Cast steel	31,200	Same as barbette	Gun iron	11,450	
	do	1896	do	10,250	Same as 1894 model; 32 gallons neutral oil.	12	5		45,250	Spur ring attached to base ring, and gearing.		27,000	
	Disappearing, A. R. F	1896								Same as L. F			
	Casemate	1894								Same as barbette			
12-inch B. L. R.	Barbette	1892	Cast steel	17,590	Hydraulic cylinders; 50 gallons neutral oil.	15	7	Cast steel	46,670	Traversing chain and gearing.	Cast iron	34,120	Platform, crane, etc., 14,424 pounds.
	Disappearing, L. F	1896		25,500	Hydraulic cylinders; 70 gallons neutral oil; counterweights.				73,882	Spur ring attached to base ring, and gearing.		34,290	
	Disappearing, A. R. F	1896			do					Same as L. F			
	Gun lift	1891	Cast steel	20,608		20	7	Cast steel	14,400	Same as barbette	Cast iron	26,500	Upper roller path, 23,100; accessories, 20,028.
	Casemate	1894								do			
16-inch B. L. R.	Barbette	1891											
12-inch B. L. M. [cast iron].	Spring return	1891	[1] Cast steel [2] Gun iron	1,806 11,750	Hydraulic cylinders; 12 gallons neutral oil.	65		Gun iron	24,500	Spur ring attached to base ring, and gearing.	Gun iron	16,250	[1] Trunnion carriage. [2] Side frame.
		1896			do								
12-inch B. L. M. [steel].		1896	Gun iron	4,970	do			Gun iron	28,500	Same as model 1891	Gun iron	14,500	
15-inch S. B.	Barbette [low rail]		Steel	7,350	Hydraulic cylinders; 25 gallons neutral oil.				19,665	Traverse wheels			
	Barbette [high rail]		do						21,161				
8-inch M. L. R.	Casemate		do	1,925	Hydraulic cylinders; 13 gallons neutral oil.				6,560	do			For low traverse circle.
	Barbette, F. P.		do	2,100	do				9,305				For high traverse circle.

SIGHTS.

SIGHTS AND OTHER MEANS OF GIVING ELEVATION AND DIRECTION.

Smooth-bore guns.—Direction by sights, or by traverse circle graduated in azimuth.

Elevation by the quadrant or by the elevating arc. The elevating arc consists of a strip of brass attached to the base of the breech parallel to the ratchets. It is graduated into degrees and parts of degrees, and a pointer attached to the ratchet post indicates the elevation of the piece.

8-inch M. L. R.—Direction by the sights, or by the traverse circle graduated in azimuth.

Elevation by sights, quadrant, or elevation indicator.

8, 10, 12, and 16-inch B. L. R.—Direction by sights (top or side), or by azimuth graduations on the traverse circle.

Elevation by sights (ordinary or telescopic), quadrant, or elevation indicator.

12-inch B. L. M.—Direction by traverse circle graduated in azimuth.

Elevation by quadrant.

Rapid-fire and machine guns.—Special sights.

TOP SIGHTS.

Top sights consist of a simple notched rear sight without means of giving elevation or deflection, and a point front sight. They are used in proof firing for very short range, or for aiming the gun for direction only.

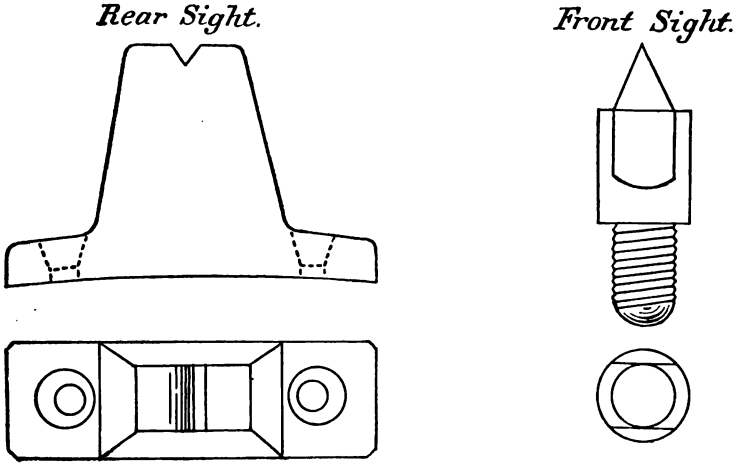


Fig. 9.

SIDE SIGHTS.

The front sight consists of a single piece fastened to the gun by two screws; its upper extremity terminates in a blade.

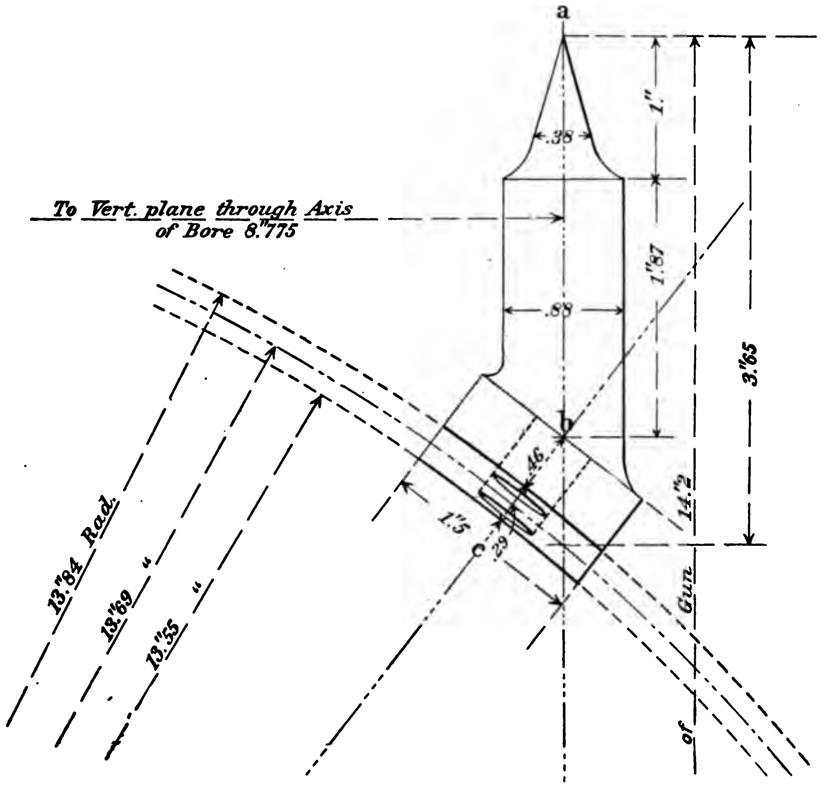


Fig. 10.

The rear sight consists of a tangent scale with level. It is graduated from 0 to 8 degrees, and reads to minutes. It is provided with a deflection scale graduated in thousandths of the range; the scale is operated by a translating screw.

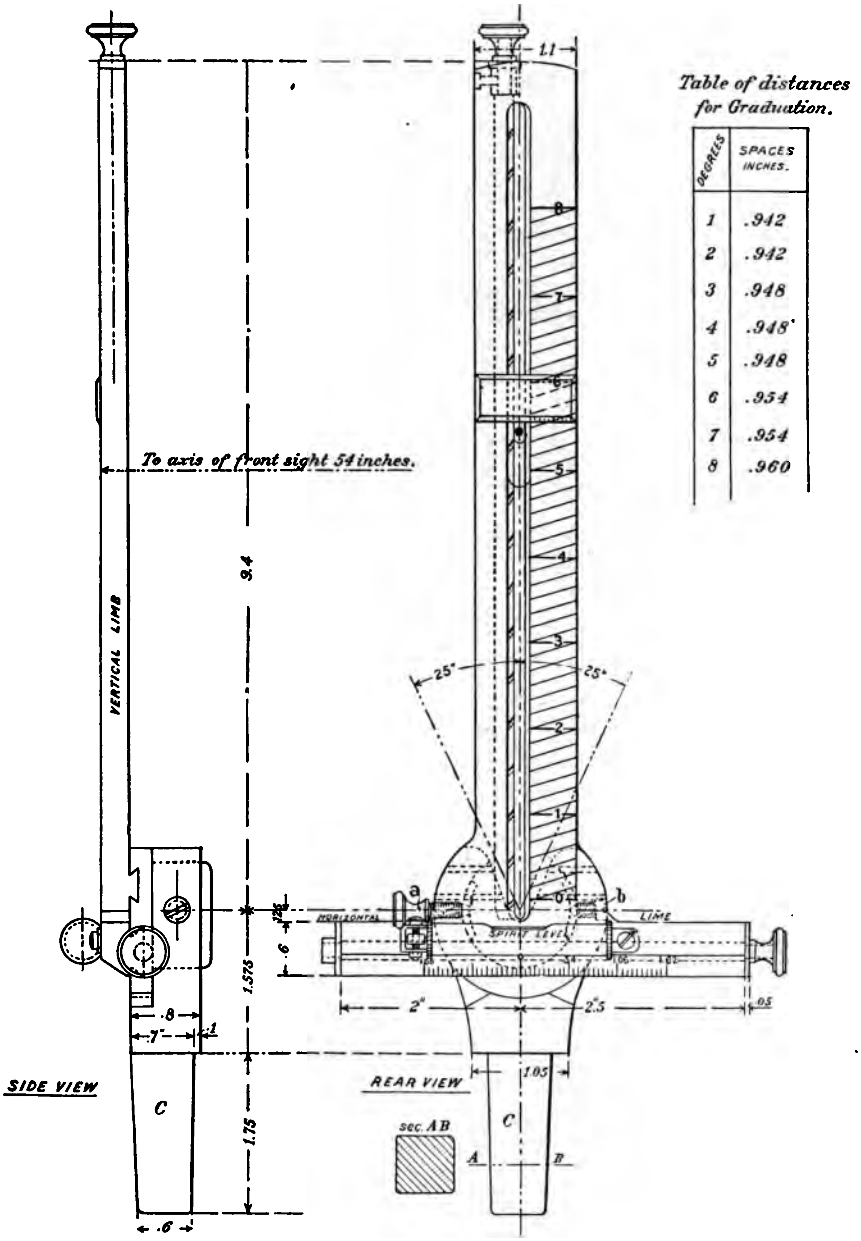


Table of distances for Graduation.

DEGREES	SPACES INCHES.
1	.942
2	.942
3	.948
4	.948
5	.948
6	.954
7	.954
8	.960

Fig. 11.

SIDE SIGHTS FOR THE 8, 10, 12-INCH B. L. R.

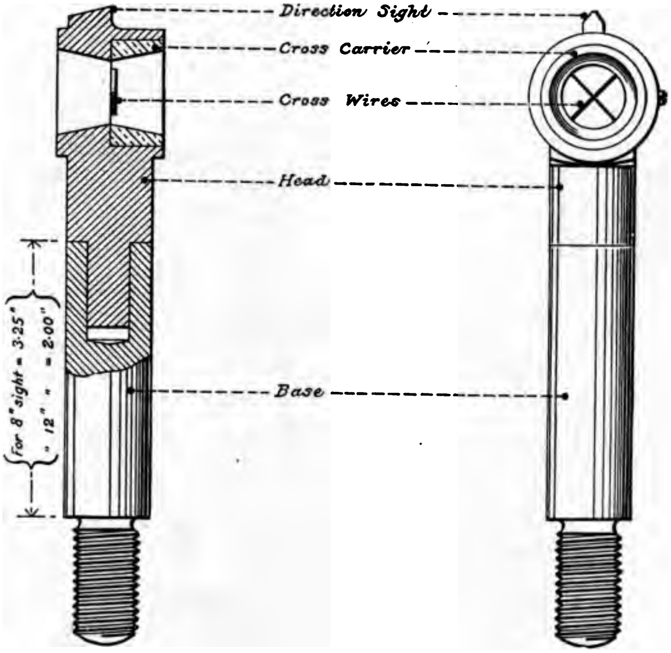


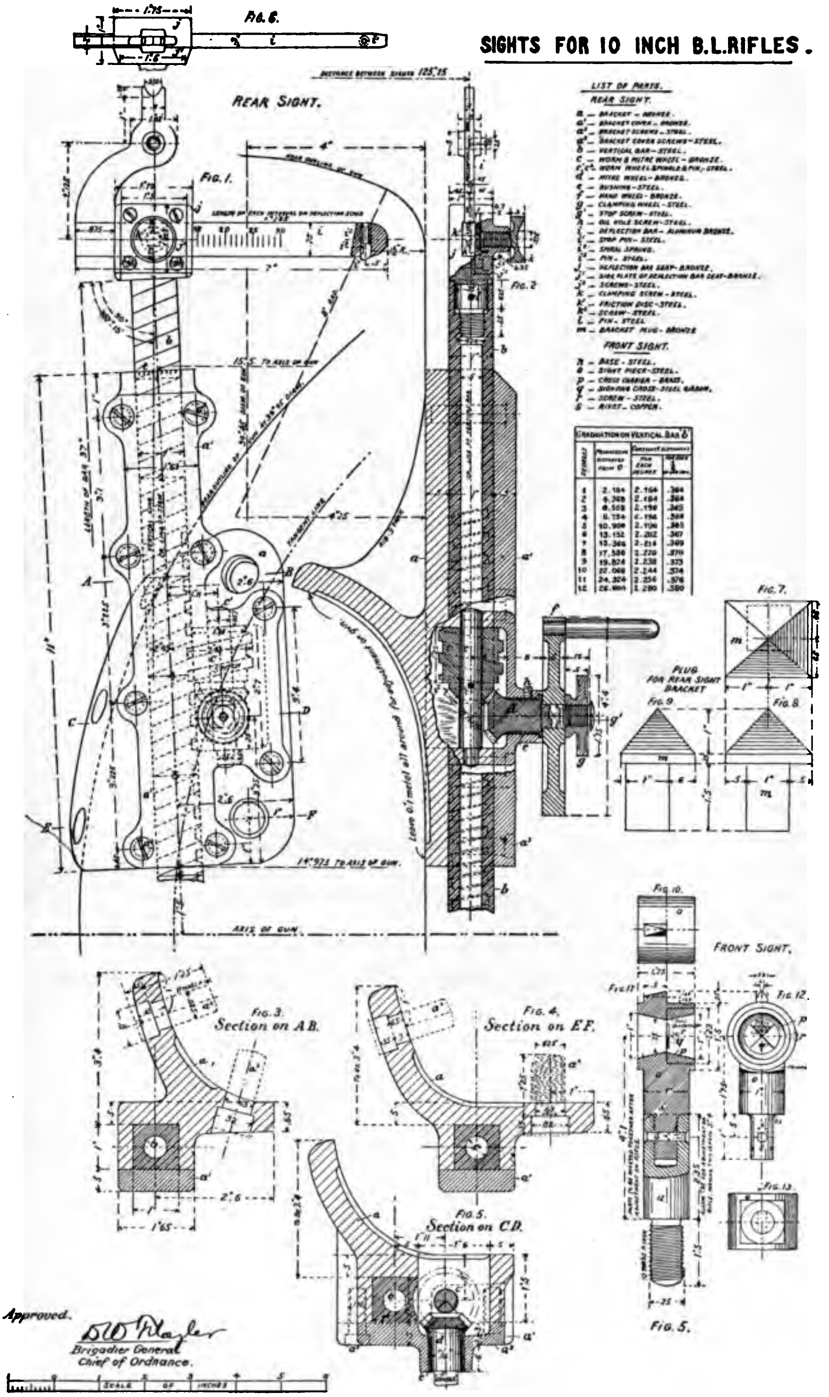
Fig. 12.

The front sight is made in two parts, the head fitting into the base, which is left with an excess of length, in order that the position of the cross wires may be accurately adjusted at the proper height by filing off the top surface of the base after it has been screwed in its seat.

The rear sights are made of bronze and steel, and are composed of the following principal parts and the necessary screws for assembling and securing the sights in place:

Base.
Vertical limb.
Worm.
Deflection scale.
Miter gear.
Deflection screw.
Elevating wheel and shaft.
Sighting leaf.
Vernier.

SIGHTS FOR 10 INCH B.L.RIFLES.



LIST OF PARTS.

REAR SIGHT.

a — BRACKET — BRONZE.
a' — BRACKET COVER — BRONZE.
a² — BRACKET SCREWS — STEEL.
a³ — BRACKET COVER SCREWS — STEEL.
b — VERTICAL BAR — STEEL.
c — WORM & MITRE WHEEL — BRONZE.
c', c² — WORM WHEEL SPINDLE & PIN, — STEEL.
d — MITRE WHEEL — BRONZE.
e — BUSHING — STEEL.
f — HAND WHEEL — BRONZE.
g — CLAMPING WHEEL — STEEL.
g' — STOP SCREW — STEEL.
h — OIL HOLE SCREW — STEEL.
i — DEFLECTION BAR — ALUMINUM BRONZE.
i' — STOP PIN — STEEL.
i² — SPIRAL SPRING.
i³ — PIN — STEEL.
j — DEFLECTION BAR SEAT — BRONZE.
j' — SIDE PLATE OF DEFLECTION BAR SEAT — BRONZE.
j² — SCREWS — STEEL.
k — CLAMPING SCREW — STEEL.
k' — FRICTION DISC — STEEL.
k² — SCREW — STEEL.
L — PIN — STEEL
m — BRACKET PLUG — BRONZE

FRONT SIGHT.

n — BASE — STEEL.
o — SIGHT PIECE — STEEL.
p — CROSS CARRIER — BRASS.
q — SIGHTING CROSS — STEEL GARDEN.
r — SCREW — STEEL.
s — RIVET — COPPER.

GRADUATION ON VERTICAL BAR b

[illegible]	Progressive distances from 0	Consecutive distances	
		For each degree	[illegible]
1	2.184	2.184	.364
2	4.368	2.184	.364
3	6.558	2.190	.365
4	8.754	2.196	.366
5	10.950	2.196	.366
6	13.152	2.202	.367
7	15.366	2.214	.369
8	17.586	2.220	.370
9	19.824	2.238	.373
10	22.068	2.244	.374
11	24.324	2.256	.376
12	26.604	2.280	.380

Approved.
D W Flagler
Brigadier General
Chief of Ordnance.

Fig. 13.

The base is made of bronze and secured, on the left side of the gun to the rear face of the outside hoop, by screws. It supports the vertical limb and the gearing that operates it.

The vertical limb is a square steel bar with a hole bored through it lengthwise to decrease its weight. It is graduated on its rear face. The least reading is 10 minutes, but by means of a vernier a reading to 1 minute can be made.

The 8-inch sight is graduated up to 15 degrees of elevation; the 10-inch, 12; and the 12-inch, 10. The deflection bars are all graduated to thousandths of range.

For the 8-inch rifle, the line of the so-called vertical limb is inclined 2 degrees and 30 minutes from the vertical as a correction for drift; for the 10-inch and 12-inch rifles, the inclinations are, respectively, 2 degrees and 45 minutes, and 3 degrees.

The upper end of the vertical limb carries the sighting leaf, and the deflection bar and screw. The sighting leaf has a notch for quick sighting, and a peephole for finer adjustment. The notch is used in conjunction with the triangular top of the front sight, and the peep, with the cross wires. The sighting leaf is made lighter by the removal of the superfluous metal beneath the peep.

The sight leaf is moved to the right or left by turning the deflection screw, which has milled heads at both ends.

The sight is raised or lowered by turning a handwheel which rotates gear wheels and a worm.

HORIZONTAL LIMB FOR COAST RIFLE SIGHTS.

The *horizontal-sight limb*, shown in figure, is now undergoing trial. It consists of a deflection scale with a curved arm at one end projecting upward and carrying a peephole and a notch for a direction sight. The limb slides horizontally through the head of the vertical limb. A reading in the opposite direction to that shown in the drawing can be obtained by pressing the spring stop pin, removing the limb and inserting it from the other side. The limb is graduated on both sides.

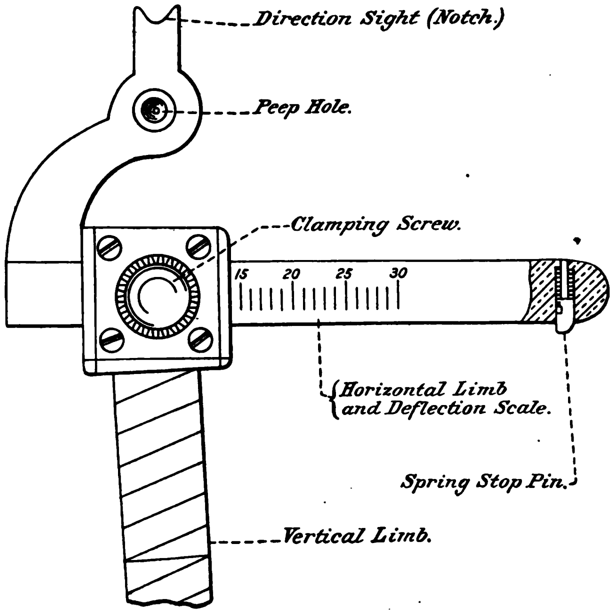


Fig. 14.

THE GUNNER'S QUADRANT.

This instrument is used on all kinds of guns and mortars, either to give the elevation directly or to verify the angles obtained by ordinary sights. It is applied to the breech of the gun, to the face of the muzzle, to an element of the bore, or to an element of the exterior surface when the latter element is parallel to the axis of the bore, as may be most convenient.

It is graduated from 0 to 44 degrees on one face and from 45 to 89 degrees on the other face; an arrow indicates the direction in which the instrument must be placed when using either face. The sliding level is set for minutes on the arm which is graduated from 0 to 60.

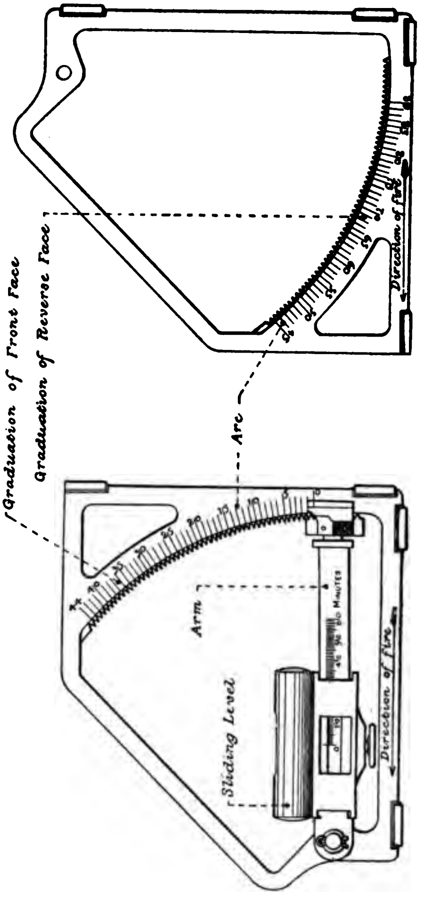


Fig. 15.

AZIMUTH GRADUATIONS.

The Azimuth of an object is the horizontal angle included between the meridian and the direction of the object; it is measured from the south to the west in the northern hemisphere, increasing in a clockwise direction from zero to 360 degrees.

Azimuth circles on gun carriages or platforms are graduated in degrees, the reading increasing as the gun turns clockwise, being zero when the gun points south and 90 degrees when it points west. The vernier or indicator is placed at some point of the arc convenient to the gunner; but wherever it is placed, it should read zero when the gun points south and 90 degrees when it points west.

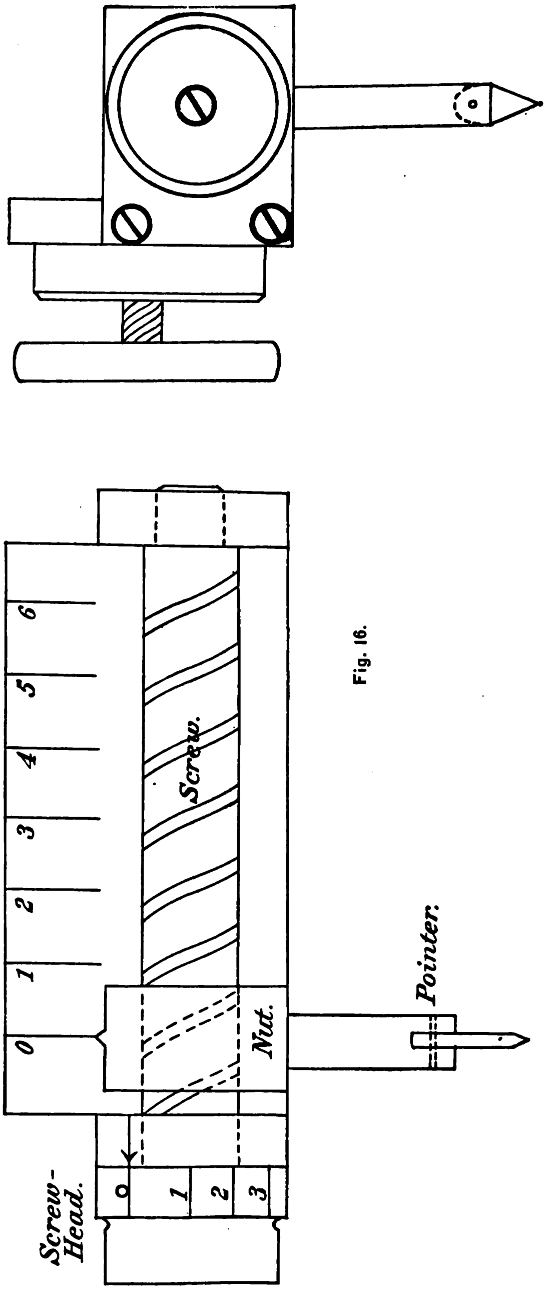


Fig. 16.

Scale "A" covers one degree and is divided into six parts showing ten-minute readings. The screw-head is divided into ten parts, one turn corresponding to ten minutes.

This device is attached to the carriage. To use it, set off the *minutes* on the indicator by turning the screw and traverse the gun until the pointer is at the proper *number of degrees* on the azimuth circle.

The following instructions for the orientation of the guns of the different batteries constituting the fire commands of a fort or artillery district, and for setting the verniers and numbering the graduation of the azimuth circles on the gun carriages or platforms to read azimuth angles of directions from the gun pintles to objects in the field of fire will be observed:

Select and establish a line to be used as the standard base of the survey and harbor chart. Measure its length and determine its azimuth. Verify the work, and mark the extremities of the base and such intermediate points as may be found useful, permanently on the ground. Locate the pintles of the guns and other important points with reference to the standard base. Calculate the azimuths of the direction from the pintles of the different guns to some one or more conveniently located points in the common field of fire. Train the guns on one of these points; set the verniers to read the calculated azimuths of direction, and, after having verified on some other point whose azimuth from the gun pintles is known, mark permanently the numbers on the graduation of the azimuth circles to read the calculated azimuths of directions.

It is advisable that the work of locating the gun pintles with reference to the base line should be done after the base rings have been set but before the carriage and gun are mounted, and that, when the sites have been selected, the stations for the position-finders should also be located and, after the installation of the instruments, their position and that of the guns with respect to them verified.

A careful record and plat of this work will be kept for reference, so that it may be taken up and continued as alterations and additions to the armament are made.

Elevation indicator for barbette-carriage (see Plates—Page VIII) consists of a brass arc graduated to half degrees attached to the carriage, a rack attached to the left trunnion, and gearing with a pinion attached to the pointer or finger pivoted to the trunnion cap. By means of a vernier on the end of the finger, the device reads to two minutes.

Elevation indicator for disappearing-carriage consists of a graduated circular brass index plate, secured to the large elevating spur wheel by screws, and a pointer attached to the chassis.

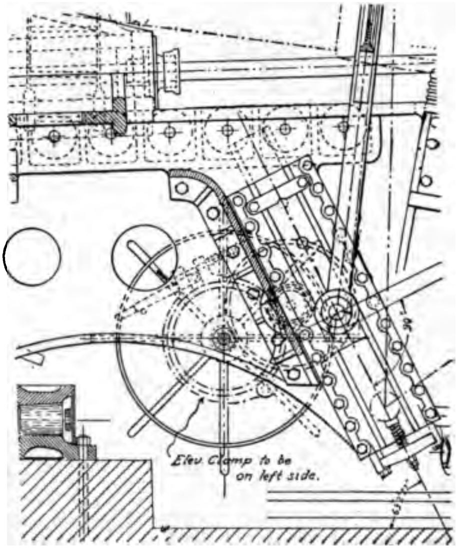


Fig. 17.

Owing to the character of the motion, the distance between the degree marks is not constant, and therefore the plate must be graduated after the gun is mounted. The indicator reads to minutes.

POINTING ARC.

(See Plates—Page VIII.)

The pointing arc consists of a level sliding on a graduated arc which is attached to the gun. By means of it, elevations to 20 degrees can be given. It reads to two minutes. A yard scale can be attached to it. It is provided with sights for direction and a deflection scale.

POSITION-FINDERS.

Two classes of position-finding instruments are used with coast artillery, viz:

1. THE DEPRESSION POSITION-FINDER (D. P. F.).

The working base in this instrument is vertical, it being the actual height of the horizontal axis of the telescope above sea-level at the moment of taking an observation. The range in yards and the direction in degrees and minutes of arc are read directly from the indicator-dials. The range-scale is so constructed as to apply automatically the proper correction for effects of curvature and normal refraction. The correction for effects of abnormal refraction is made by an independent mechanical device which gives a slight vertical movement to the telescope without changing the range indication. There is also an instrumental adjustment to adapt for changes in length of base due to rise or fall of tide.

Ranges found with this instrument must be either wholly, or in part, over the surface of the water, and the object observed must have a water-line.

2. THE HORIZONTAL BASE POSITION-FINDER (H. P. F.).

This consists of two quick-reading, azimuth instruments, one at each extremity of a horizontal base-line of considerable length, combined with a quick-plotting device located at one of the base-end stations or at some point in the battery.

The base-end stations should have reliable electrical communications with each other and with the replotting station.

Instruments of this class will be required when the site of the battery and vicinity are low, and provision should be made *in every case* for resorting to them as an auxiliary when the water-line is obscured in any way.

On account of the number of stations and operators required, the difficulty experienced in identifying targets, and the length and complexity of the lines of communication involved, instruments of this class will be used exclusively only when the site of the battery and surrounding fortifications or country are too low to afford proper elevation for mounting a D. P. F.

With either class of position-finder, it is important that each battery or independent group of guns should have its own position-finding system.

The depression position-finder: Two types are issued for service:

Type A is a large instrument, equipped with a powerful telescope, and permanently installed upon a masonry or cement foundation at a distance from the guns of the battery. The cast-iron table is provided with one or more replotter arms for the quick conversion of ranges and azimuths, as given by the *dials of the instrument,* into corresponding ranges and azimuths for the *directing gun* of the battery. The lines of communication between the P. F. station and the guns are of permanent character, the wires being laid in underground conduits.

When properly installed at an elevation of 50 feet, or more, above sea-level, instruments of this type give accurate results at all ranges under 10,000 yards. Thirty-five feet elevation is sufficient to give service accuracy up to 7,000 yards.

The approximate height at which the particular instrument is to be used should be known before it leaves the shop, in order to bring the scale-adjustments, for changes in altitude, within as narrow limits as possible. Scale-limits from 10 feet above to 10 feet below a given mean elevation are ample to meet any service requirement.

The scale on the plotting-arm is 400 yards to the inch, divided and numbered into hundreds of yards. The small dial carried by the pointer, which is moved by hand along the plotting-arm, is divided and numbered so as to read range intervals of five yards. The replotter-arm and the dial of its sliding pointer are similarly divided and numbered.

Type B is a light portable form of the larger one, and intended for use at or near the guns in case of accidental damage to the Type A instrument or to the lines of communication.

The general principles of construction in the two types are identical, but Type B has a much smaller telescope, has no scale arm, and is not provided with a replotting-attachment.

When working at an elevation of 50 feet, or more, the ranges are accurately given up to 8,000 yards. At 35 feet this type will give service accuracy up to 6,000 yards range.

Suitable pedestals are constructed on the rear face of each flank-traverse of the battery for setting up the instrument when needed for immediate use. Each pedestal will have permanently marked upon it the following data:

(*a*) Ranges and azimuths to a number of fixed points in the harbor.
(*b*) Elevation of axis above mean low tide when the instrument is in position.
(*c*) Rise and fall of tide in feet.
(*d*) Distance in yards to directing gun of the battery.

DESCRIPTION OF THE LEWIS DEPRESSION POSITION-FINDER, TYPE "A," MODEL OF 1897.

(See Plates—Page IX.)

Plate I shows a side elevation, and a partial section through the vertical axis of the instrument; a rear elevation of the traversing arm, with traversing, elevating, and azimuth mechanism, and the male center; and a partial horizontal projection, showing, in addition, the replotting device.

Nomenclature.

1. *Hollow cast-iron column.*
2. *Leveling screws* for column.
3. *Table,* cast-iron, 60 inches in diameter.
4. *Table edge,* cylindrical, for friction rollers.
5. *Lugs,* six in number, necessary in casting the table.
6. *Ribs,* six in number, to stiffen top of table.
7. *Traversing arm,* which supports and carries the telescope, and all parts of the traversing, elevating, and azimuth mechanism.
8. *Male center,* whose axis is the axis of the traversing arm, 18 inches long, secured to the traversing arm by screws, and extending down through table and column.
9. *Female center,* secured to table.
10. *Eyepiece* of telescope.

11. *Object glass* of telescope.
12. *Horizontal axis*, about which the telescope revolves when the elevating cylinder is moved.
13. *Arms*, attached to traversing arm, which support the front end of the telescope.
14. *Arms*, fitted to axle of telescope, which support front end of range-scale.
15. *Micrometer head* of screw, which corrects for abnormal refraction.
16. *Focusing screw.*
17. *Elevating cylinder*, moving in guides and carrying rack.
18. *Double bracket*, supporting and guiding elevating cylinder.
19. *Rack*, on elevating cylinder into which meshes the toothed arc of the elevating sector.
20. *Elevating sector.*
21. *Arm of elevating sector.*
22. *Bracket*, supporting pivot of elevating sector.
23. *Vertical elevating screw.*
24. *Bracket*, which supports elevating screw.
25. *Movable pivot*, against which the arm of the elevating sector bears.
26. *Altitude-scale*, in feet, showing the length of the vertical base.
27. *Horizontal screw*, which moves pivot 25 along scale 26.
28. *Brass plate*, secured to the nut of elevating screw, which forms support for scale 26 and screw 27.
29. *Crank*, which operates the elevating mechanism.
30. *Beveled gears*, connecting crank 29 with elevating screw 23.
31. *Azimuth pointer*, for degrees.
32. *Azimuth device*, for minutes.
33. *Box*, carrying friction roller and gearing for operating pointer of minute-dial.
34. *Pivot*, connecting box 33 with traversing arm.
35. *Minute-dial.*
36. *Head of screw*, which bears against a spring in turn bearing against box 33, to insure contact of friction roller.
37. *Friction roller*, running on cylindrical edge of table, by which the traversing arm is moved.
38. *Bevel gear* of friction roller 37.
39. *Axle*, at the end of which is a bevel-gear meshing with the bevel gear 38.
40. *Supports* for axle 39.
41. *Crank*, which operates gears 38 and 39.
42. *Plotting arm* of position-finder.
43. *Movable index*, with gearing meshing in rack on bottom of 43, whereby range readings to yards can be made.
44. *Pointer of index*, against which the replotting arm is brought.
45. *Range arm* of replotting device.
46. *Movable index*, with gearing meshing in rack cut on 45, whereby range readings to yards can be made.
47. *Minute-dial* of replotting device, which carries gearing meshing in a circular rack.
48. *Degree circle* of replotting device.
49. *Vertical axis* of traversing arm.
50. *Vertical axis* of replotting arm.
51. *Screw*, at the bottom of the female center, by means of which the bearing of the male center can be adjusted.
52. *Steel rollers*, attached to traversing arm and running on top of the table.
53. *Level.*

54. *Guard,* to protect range-wheel.
55. *Vertical axis* of range-wheel.
56. *Lag screws.*
57. *Range-scale.*

The essential parts are:

First. *A hollow cast-iron column,* resting upon three feet with brass capstan-headed leveling screws (2, 2).

To the top of this column is bolted the cast-iron table (3). The column should rest upon a solid foundation, preferably of masonry. No special precaution need be observed in setting up the column and securing the table thereto, except to see that the lag screws (56) are in their proper places, and screwed up firmly.

Second. *A circular cast-iron table* (3), 60 inches in diameter, turned perfectly true on the outer edge, and concentric therewith is turned the seat for the female center.

This table is a solid casting strengthened by deep, tapering, radial ribs (6). The top is turned, ground, and polished, as is the outer edge, on which rolls the friction roller of the azimuth device and the friction roller (37) which moves the traversing arm (7) in azimuth. The female center (9) projects downward through the table and column for a distance of 18 inches, its top flange being turned to fit the annular groove turned from the table center. The female center is a composition casting and is secured to the table by bevel-headed screws.

The projecting lugs (5, 5), six in number, are a necessity in casting the large table, and are also useful in securing and leveling the table on the lathe before turning. They are left on the completed instrument to be used as auxiliary supports in order to secure a very fine adjustment of level for the table, but are not intended to support the weight of the instrument. To utilize them as auxiliary supports, six small columns (preferably 4-inch iron pipe filled with concrete) should project upward from the foundation base to within two inches of the lower face of these lugs. Small leveling screws may be provided to engage in the lower extremity of the lug and rest upon iron caps on the 4-inch columns.

Third. *A cast-iron traversing arm* (7), which carries all the other parts of the instrument except the replotting device (45, 46, 47, and 48). This arm is pivoted at the center of the table (male center 8), and is moved in azimuth by the friction roller (37) operating on the outer edge of the table. To this arm are attached two curved arms (13) which support the horizontal axis of the telescope. The rear end of the plotting arm (42) is attached to the traversing arm. The traversing arm is a single casting, having two side ribs for stiffness, a solid core through which passes the male center, and a wide, flat, end surface, planed perfectly true, for the various parts of the elevating and azimuth mechanism to rest upon.

Fourth. *A telescope,* with a 3-inch object glass, 40-inch focal length, 25 magnifying power, and a field of view of nearly two degrees. The cross-wires are fixed in position and at right angles to each other.

The eyepiece is easily moved in or out by turning it slightly *to the right,* at the same time pushing or pulling gently.

As the range-scale is by construction corrected for the effects of normal refraction and curvature, the micrometer screw (15) is used only when abnormal refraction is apparent, or when a new tide adjustment has been made. To apply the correction for abnormal refraction, direct the telescope, after the instrument is in proper adjustment, upon the water-line of some object whose exact horizontal distance from the instrument is known, and operate the elevating crank (29) until the range-scale reads this distance. If the horizontal cross-wire is not coincident with the water-line of the object sighted on, turn the micrometer screw (15) until exact coincidence is established.

The telescope turns about a horizontal axis (12) in rear of the object glass, and all angular movements of the telescope about the axis are produced by raising or lowering the eye end at the point where the micrometer screw (15) rests upon the top of the elevating cylinder (17), called the *point of tangency.* The horizontal distance between this point and the axis is exactly 50 inches. Since, by construction, the elevating cylinder (17) can move only in a vertical direction, the point of tangency describes a right line which is the natural tangent of the angle through which the telescope is moved, the radius being 50 inches.

Fifth. *The elevating mechanism,* which consists of the following parts: Elevating screw (23) with movable nut; crank and handle (29) which turns the screw by means of the bevel gearing (30); toothed sector (20) and sector arm (21); pivot (25) which is carried transversely across the altitude-scale (26) by the small horizontal screw (27); the bracket support for screw (24); bracket support for sector (22); elevating cylinder (17); brackets supporting the same (18); toothed rack on cylinder (19).

Sixth. *The range-wheel,* not shown in drawing, but pivoted at 55. This wheel is twelve and one-half inches in diameter, the gear cut in its circumference being 48 pitch and having 600 teeth. It is mounted on the flat under surface of the traversing arm. The graduation is in black on white celluloid, which is one-sixteenth of an inch thick and set into metal. The figures show hundreds of yards of range. The scale reads directly to 10 yards from 1,500 to 6,000 yards, and to 25 yards from 6,000 yards to the end of the scale.

A small pinion is carried on the under projection of large elevating screw, and meshes with the gear of the range-wheel. A cover (54) is fitted over the wheel to protect against dust and accident; the opening in this cover has an index for reading the range-scale (57). The gears are very carefully mounted to avoid the back-lash.

Seventh. *An azimuth device* (31, 32, 33, 34, 35, and 36).

The outer top rim of the table is graduated into degrees, and each degree is numbered to read azimuth. The minutes are read directly from the dial (35). This minute-dial, with the friction roller which actuates it, is carried by a short arm pivoted on the under face of the traversing arm at 34. A short, stiff spiral spring with screw-adjustment (36) presses against this short arm to keep the roller at all times in frictional contact with the outer cylinder of the table. The short arm also carries an index (31), which marks the proper degree reading.

To adjust the device, bring the pointer of the minute-dial to zero, then release the pressure of the friction roller against the table, and turn the traversing arm until the *degree index* is exactly coincident with a *degree division.* The spring pressure against the roller is then renewed, and the device is thus adjusted. When necessary, the minute-dial face may be turned slightly without moving the pointer.

Eighth. *Means for moving the telescope in azimuth* (37, 38, 39, and 41). This is done by means of a crank (41), which operates a friction roller (37) mounted on the under flat surface of the traversing arm and which rolls around the outer cylinder of the table.

Ninth. *A spirit level* (53), which is used to adjust the level of the table. When in perfect adjustment, the arm may be traversed through 360° without changing the position of the bubble.

Tenth. *A replotting device,* which is used for the purpose of quickly converting ranges and azimuths as measured from the position-finder into the corresponding ranges and azimuths from the *directing gun.*

There are three essential parts to the replotting device:

(1) A brass arc, which is a gear wheel or a segment of one, and which has an arc of celluloid graduated into degrees inlaid into the face of its outer rim (48).

(2) A scale-bearing arm (45), graduated and numbered so as to read directly to hundreds of yards, pivoted at the center of the arc.

(3) A small minute-dial (47) with its necessary mechanism carried on the arm so that its small motor pinion is at all times in mesh with the teeth of the main arc. The dial is only two inches in diameter, and is graduated and numbered into minutes. A small pointer actuated by the pinion, as the scale arm is moved about its center, enables the operator to read the minutes at a glance, and without the aid of a vernier. The degrees are read directly from the large arc scale.

The scale on the replotting arm must be the same as that of the plotting arm of the position-finder.

Each of these arms carries a sliding index, with gearing which meshes in a rack cut on the arm itself, and by means of which range readings to yards can be made. The index of the plotting arm (43) has a pointer, the bottom of which barely clears the table, and whose axis moves in a vertical plane through the line of collimation of the telescope. The index of the replotting arm (46) has a cylindrical groove on the edge which moves in a vertical plane through the center of the arm, the groove just fitting the pointer of the plotting arm when placed against it.

The center of the replotting arm corresponds to the position of the pintle of the *directing gun* of the battery which it serves. The size of the main arc will be determined by the field of fire of that gun. Ordinarily the field of fire will not exceed 120 degrees, but in certain special cases it may be all-round fire, in which case the replotter arc would have to be a circle.

PRECAUTIONS TO BE OBSERVED IN SETTING UP THE INSTRUMENT.

Put column in place over the center of the foundation pier, and see that the leveling screws project through the feet about one inch and rest in the cast-iron cups provided for that purpose.

The table is then lifted and placed on top of the column and the lag screws (56) put in, and firmly screwed in place. Both centers should be examined, cleaned, and oiled, and the adjusting screw (51) on the bottom should be turned until the weight of the male center rests entirely on the bottom, while the side and top surfaces should remain in contact.

When the centers have been adjusted, the shank of the male center is passed through the hole in the hub of the traversing arm, the shoulder fitting into the annular recess turned in the bottom of the arm, and the center is firmly secured to the arm by screws engaging in the shoulder from above. The traversing arm with all the parts assembled upon it is then lifted into place, care being taken that the male center is let down to its position without being scraped or bruised. The rear end of the traversing arm is supported by the two steel rollers (52, 52), which run on the top of the table and prevent strain on the male center.

If the arc of the replotting device is a complete circle, and the distance of its center (when adjusted in position) from the cylindrical part of the male center is less than the radius of the inner circle of the arc, the device must be placed on the table, although not accurately adjusted in position, before the traversing arm is lifted into place.

All parts carried on the arm are shipped in place, and it will only be necessary to see that all are clean, a little good oil dropped on the wearing surfaces, and that all the parts move freely without binding.

The next step is to carefully level the table by means of the three leveling screws in the feet, and, finally, in getting a very perfect level, the six small leveling screws in the projecting lugs are used, if in position; but it should be remembered that these latter are not intended to support the weight of the table, and should only be brought into use to counteract the effect of flexure in the metal. When the leveling is properly done, it will be possible to move the arm through an entire circumference without displacing the bubble.

The bracket, which supports the friction roller (37) underneath the traversing arm, must be screwed very firmly into place by means of the three large screws which extend entirely through the arm from the top surface. This will give all the friction necessary to operate the crank mechanism, and to turn the arm about its center. If at any time during the use of the position-finder this roller should begin to slip, tighten these three screws at once.

To make a *first adjustment* of the *elevating and range mechanism*, see that the table is properly leveled and that the parts are in place as described; also see that all parts of the elevating mechanism are in good working order. The parts should work smoothly and easily without the slightest sound. Having determined the exact height of the horizontal axis of the telescope above mean low tide, apply correction as shown by the tide-gauge, and set the elevating pivot (25) at the proper division of the altitude-scale. Direct the telescope upon some distant datum point, and turn the elevating crank (29) until the range-scale (57) reads the distance of the observed datum point. Look through the telescope and, if the horizontal cross wire is only slightly above or below the water line, establish coincidence by means of the micrometer screw (15). If the displacement is too great to be corrected in this way, then unmesh the elevating sector (20) from the rack in the elevating cylinder (19), and raise or lower the cylinder (17) the required amount. The sector is then put in mesh with the rack, secured in place, and the adjustment finally completed by means of the micrometer screw (15). Once adjusted in this manner, the sector should not again be unmeshed unless it becomes necessary to remove or repair the instrument. The micrometer screw (15) will always provide a movement of sufficient range to correct for all atmospheric changes.

The orientation of the position-finder is effected as follows: Before the traversing arm is put in place, the table is oriented approximately by sighting over its center at a datum point, making due allowance for the position of the degree pointer. When the traversing arm has been lifted into place and the table approximately leveled, the telescope is directed on the datum point, and, if its azimuth is not indicated by the degree pointer within a degree, the table must be turned bodily about its center, a little at a time, until the degree pointer will, when the telescope is directed on the datum point, indicate its azimuth to a fraction of a degree. The table is then accurately leveled and the telescope directed on the datum point. The small changes which may then be necessary to secure a correct azimuth reading, in degrees and minutes, can be made by adjusting the minute-dial and the degree pointer, each of which has an adjusting movement of one degree.

The horizontal scale, carried on the brass plate attached to the elevating nut (28), is called the altitude-scale (26), and indicates the exact height in feet of the horizontal axis of the telescope above the surface of the water. As this distance is, by construction, the working base of the instrument, and since it is increased or decreased by the fall or rise of the tide, a *tide-gauge*, which shows the height of the tide in feet above or below mean low tide, will be necessary for the correct use of the position-finder. When first set up, the height of the horizontal axis of the telescope above mean low tide is very accurately determined. A table is then prepared and posted near the instrument, showing the exact length of the working base for each reading of the tide-gauge, so that the operator, as soon as he knows the tide reading, will know at a glance the correct reading on the altitude-scale at which to set the index of the elevating pivot (25). This can be quickly done by means of the screw (27). It will be found in practise that this correction will not have to be made oftener than once an hour unless the tidal changes are very considerable; but, since the correction can be made in a moment, it is well to read the tide-gauge frequently.

To place and secure the replotting device in position.—This is effected, after all the other adjustments have been made, as follows: Direct the telescope on the point for which the replotting is to be done, or, if this point can not be seen, set the telescope at the azimuth of the point. Determine, by means of the pointer (44), two points on the table, one near the outer circumference and the other near the center, which are in the intersection of the vertical plane through the line of collimation of the telescope, when in the position described, with the top of the table. A right line drawn through these points will contain the center of the replotting device, which center will be at a distance from the vertical axis of the traversing arm equal to the distance from the position-finder to the point for which the replotting is done, *to the scale of the position-finder*. With this point as a center describe an arc on the table which will contain the axes of the three screw holes in the brass ring which secures the azimuth scale of the device to the table, and determine on this circle three points 120 degrees apart. Drill holes in the table at these points for the retaining screws, and place the brass ring in position, screwing it down, but without sending the screws entirely home. Now direct the telescope on some datum point whose range and azimuth, from the point for which the replotting is done, is known, move the index (43) until it gives the distance of the datum point from the position-finder, and then move the arm (45) so that its index can be brought in contact with the pointer of 43. Keep the arm in this position and set the minute-dial (47) to read the minutes of the azimuth of the datum point from the point for which the replotting is done; move the arm (45) contra-clockwise until the minute-pointer goes back to zero, and hold the arm in this position until the azimuth circle (48) is turned so that the division, numbered to correspond to the degrees of azimuth of the datum point measured from the point for which the replotting is done, coincides with the degree index of 48. Verify this setting by using other datum points, and then screw the brass ring of the device firmly to the table.

The instrument should be protected from moisture and dust when not in use, and it is advisable to keep it covered with a rubber cloth or oilcloth. The parts should be oiled occasionally and kept free from dust. All steel parts will be found to be polished or nickel plated, except the large elevating screw (23), which should be kept thoroughly oiled. The table top and outer cylinder should also be kept free from rust by the frequent use of vaseline.

All parts of the instrument are strong and well made, and none are likely to get out of order. Care should be exercised in using it, however, since the accuracy of the results obtained will depend largely upon all the parts being kept in good working order.

Only commissioned officers or specially instructed enlisted men should be permitted to use the instrument.

INSTRUCTIONS FOR OPERATING THE INSTRUMENT.

It is assumed that a *tide-gauge* can be seen from the instrument, and that the correction table for the *altitude-scale* has been prepared and posted near the instrument; that the exact *distance and azimuth* from the position-finder to objects having a well-defined water line, at short, medium, and long range, have been determined and posted; and that the instrument has been set up and adjusted in accordance with the directions given.

Verify the level of the table.

Make the necessary correction for tide on the *altitude-scale*.

Direct the telescope on one of the datum points, setting the *range-scale* to the proper reading, and make the correction for *abnormal* refraction.

Verify the azimuth reading of the position-finder.

Verify the adjustment of the replotting device.

By setting on datum points at short and long ranges, the amount of correction for abnormal refraction at varying ranges can be determined.

The instrument is now ready for use. To obtain the *azimuth and distance* of an object from the position-finder, turn the crank (41) in the proper direction until the vertical wire of the telescope is on the desired point of the object, at the same time turning the crank (29) until the horizontal wire cuts the object on the water level. If the range *differs materially* from the *last one* taken, make the necessary *correction for abnormal refraction* by means of 15. The range and azimuth are then read on the respective scales. If the *replotted* range and azimuth are desired, the observer will, after having determined the range as above, call it out to the assistant, who moves the index (43) to read this range, and then moves the arm (45) and the index (46) until the groove of the latter fits accurately to the pointer (44). The *replotted* range and azimuth are then read from the scales on the replotting device.

LEWIS DEPRESSION POSITION-FINDER, TYPE "B," MODEL 1897.

(See Plates—Page X.)

Nomenclature.

1. *Traversing plate,* circular, metal.
2. *Metal arms,* attached to traversing plate, supporting horizontal axis of telescope.
3. *Horizontal axis of telescope.*
4. *Eyepiece.*
5. *Object glass.*
6. *Band* attached to the bar carrying the altitude-scale, holding the rear end of the telescope.

7–8. *Standard,* attached to traversing plate, supporting the elevating mechanism.

9. *Milled head* of screw operating the elevating mechanism.
10. *Conical point* attached to nut operated by 14, moving in the groove on top of 39, which is the point of support of the eyepiece of the telescope.
11. *Micrometer screw* for adjusting purposes and for correcting for abnormal refraction.
12. *Index of altitude-scale* on the face of the nut operated by 14.
13. *Altitude-scale.*
14. *Milled head* of screw attached to 13 and by the turning of which 12 is moved toward or from the horizontal axis of the telescope.
15. *Female center,* screwed to azimuth ring (24) and terminating in a hemispherical ball.
16. *Lower plate,* supporting the three leveling screws (17, 17) and having in the interior of its upper end a socket enclosing the ball on the lower end of 15.
17. *Leveling screws.*
18. *Frame,* screwed to female center, in which the leveling screws work.
19. *Hollow cylinder,* projecting from the lower plate, which fits between the rings (35) and (36) of the base plate (37).
20. *Azimuth dial,* for minutes.
21. *Head of pinion,* attached to the traversing plate, which meshes in the teeth of the azimuth wheel (24).

22. *Brass plate* to which the traversing plate, the male center, and the arms (2) are secured.
23. *Level.*
24. *Azimuth wheel,* divided into degrees.
25. *Range-wheel,* operated by the pinion (28).
26. *Index* for 24.
27. *Index* for 25.
28. *Pinion* which is turned by 9, and which meshes in teeth of range wheel.
29. *Male screw,* attached to 9.
30. *Female screw* working on 29, and which has a motion of translation only. This screw is attached to 39.
31. *Pin* on 30, moving in slot (32), to prevent motion of rotation in 30.
33. *Focusing screw.*
34. *Male center,* attached to traversing plate.
35. *Inner cylinder* of base plate (37).
36. *Outer split ring,* attached to base plate and clamping about 19 by means of the clamp screw (38).
37. *Base plate,* set securely in concrete, and approximately leveled when set.
39. *Cylinder* to which the female screw (30) is attached and on top of which is cut a groove in which the point (10) moves in a vertical plane through the line of collimation.

The principles of construction are the same as for the Type "A" instrument. It is made as light as is consistent with strength in order to secure portability, and is intended for use as an emergency position-finder at the battery, or as the instrument at the principal station of a horizontal base.

To set up and adjust the instrument.—The base plate is first set securely in concrete and approximately leveled when it is set up. The clamp ring of the base plate being loosened, the instrument is placed in position on this plate; by turning the pinion (21), the azimuth reading of the datum point on which the instrument is to be adjusted is obtained; without disturbing this azimuth setting, the instrument is turned in its seat on the base plate, and if necessary the elevating mechanism is used to elevate or depress the telescope, until the line of collimation is directed on the datum point; the instrument is then accurately leveled and the line of collimation brought back to the datum point if it has been moved off during the leveling process; the clamp screw is tightened and the level of the instrument verified. The line of collimation is again directed on the datum point, if off, and the azimuth reading and level verified. If the azimuth reading is out, the slight change necessary to correct it can be made by turning the dial of the *minute* device until the correct reading is given. The instrument is now set in *azimuth.*

The datum point selected for the preceding adjustment being preferably one with a water line, the range-scale is made to indicate its range by means of the screw (9) and the index of the altitude-scale is set for height due to state of tide. If the horizontal hair is not on the water line of the datum point, it is brought there by means of the screw (11).

To make sure of the correct adjustment of the instrument, it would be well to direct the telescope on other datum points at varying ranges, and in this way also the amount to be allowed for abnormal refraction at different ranges can be ascertained and noted, always being careful to see that the instrument is kept accurately leveled.

The instrument is used in a similar manner to that described for the Type "A," except that there is no replotting attachment.

RAFFERTY DEPRESSION POSITION-FINDER, FOR HEIGHTS FROM 30 TO 60 FEET.

(See Plates—Page XI.)

[Plates III and IV.]

This instrument is designed to obtain the range and azimuth of an object from the observing station.

It consists of a lower limb, *B*, and an upper limb, *A*. The function of the lower limb is to level the instrument and to carry the azimuth ring, *b*, which is graduated to degrees, degree spaces being alternately black and white; a pinion with milled head, b^2, rotates the ring, *b*, when adjusting the instrument in azimuth. Three leveling screws, *a*, have feet shaped so as to fit in V-shaped grooves on the foundation, and so that they may be clamped to the foundation by slotted levers; the instrument is thus rigidly attached to its foundation without interfering with the use of the leveling screws. The rest of the angle-measuring part of the instrument consists of the worm, *W*, on the under surface of the upper limb, which works in a worm gear cut on the cylinder, *w*, of the lower limb; the worm is rotated by the wheel *X*, which is pivoted on the upper limb, and which is graduated into two degrees of sixty minutes each, one degree of sixty minutes being marked black, and one degree white; the black degree of this wheel which causes two degrees horizontal circular motion in one of its revolutions, corresponds to a black degree on the ring, *b*, and the white degree on this wheel corresponds to a white degree on the ring, *b*. In using both the degrees and the minutes, the *space* is considered and the *space* is numbered; the reading is the number of degrees or minutes which is opposite the index. For use in adjustment, two clamp screws attach the graduated part of the wheel *X* to its gear. A spring pressing against the worm frame secures uniform contact of the worm in its gear; when leveling and transporting, the worm is withdrawn from engagement by a handle under the disk, *N*, near t^1, and is clamped out of gear by the lever, x^1.

On the upper limb, *A*, is mounted a frame, *F*, having two side rails, *D*, and it carries the parts used in finding ranges and the levels, *L*. Attached to the telescope, *C*, by the two brackets, *K*, *K*, is the parallel circular bar, *c*; this bar supports a travelling carriage, *m*, the movement of which along the bar, *c*, is effected by a handle, *n*. This carriage, *m*, has two pivots, *p*, *p*, which rest in shoes, *s*, *s*, and the latter rest on the side rails, *D*, of the upper limb, *A*; the telescope, *C*, is pivoted, therefore, on the pivots, *p*, *p*. On one side rail, *D*, is a scale of heights; knowing the height above the surface of the water, the handle, *n*, is operated to move the carriage, *m*, until the index on the shoes, *s*, is at the known height, according to the scale on *D*.

A third bracket, *H*, fixed to the telescope near the eye end, rests on the nut, *M*, which moves vertically, due to the turning of the screw, *J*, and the guiding of the frame, *F*. The male screw, *J*, having a range disk, *N*, rigidly attached to it, works in a female screw in the nut, *M*, and the motion of the range disk raises or lowers the nut, and through it, the eye end of the telescope.

The range index is a travelling carriage which is guided by a radial jointed arm, *R*; this arm is pivoted on the screw *J*, thus the arm, *R*, may have a rotary adjustment about this screw, and also an adjustment radially to the range disk, *N*; this arm is clamped in any position by the clamp-bar, *t*, which, actuated by the thumb-screws, *t′*, *t′*, presses the arm against the bracket. The bar, *t*, has a graduation representing a scale of heights, which scale is used in conjunction with the scale in *D*, and is a guide for the correct setting of the jointed arm, *R*, at different heights. To set *R*, correctly, straighten it and place it so that its reading is the height; then hold the inner branch of *R* with one hand and with the other bring the other branch to a position such that its reading edge crosses the arrow point in front of 45; then clamp with the screw, t′.

The range disk, *N*, is geared, and rotary motion is given to it by the pinion, *P*, operated by the handle, *q*.

Operation.

Set both height scales at approximately the correct height.

Level.

Set range-scale at the range of some datum point at short range where refraction is small, say from 2,000 to 3,000 yards. Sight on this point and move the carriage, *m*, until the horizontal hair is on the water-line; the two height scales should then correspond.

Sight on a long-range datum point, and if slightly out, move outer branch of jointed index arm to the correct range.

To adjust in azimuth, direct the telescope on a point the azimuth of which is known; set the degree scale first at about its correct position; then unclamp the minute wheel and set that correctly on the corresponding color, and clamp; turn the minute wheel to zero, and then turn the degree ring until the index is on the line between the two degrees.

REPLOTTING DEVICE.

Designed by Board on Regulation of Coast Artillery Fire.

(See Plates—Page XII.)

[Plate V.]

Nomenclature.

1. *Cast-iron frame,* one and one-half inches deep, with three flanged ribs running out from near the center to the circumference.
2. *Segment celluloid,* one-quarter of an inch thick, secured to the flanges on the ribs of the frame by screws from underneath.
3. *Pivot* of left-hand arm.
4. *Pivot* of middle arm.
5. *Pivot* of right-hand arm.
6. *Left-hand arm.*
7. *Middle arm.*
8. *Right-hand arm.*
9. *Slider,* with pencil (13).
10. *Slider* on the middle arm which carries gearing meshing by a pinion with the rack cut on the arm.
12. *Slider,* with pencil (11).
14. *Index* on (7) for determining azimuth and range of point of intersection of lines from (3) and (5).
17. *Connecting bar* pivoted at 15 and 16.
20. *Connecting bar* pivoted at 18 and 19.
21. *Toothed wheel,* fastened to the frame, which actuates the minute-device when the arm (7) is moved about the pivot (4).
22. *Minute-device,* with gearing meshing with 21.
23. *Degree index* on 7.
24. *Mark on board,* at right angles to the diameter, which indicates the bisecting line of the angle (3), (4), (5), to which the index (14) is set when adjusting the azimuth reading.

A *special pencil sharpener* is furnished with the device in order that the pencil points shall always be in the axes of the cylinders on the sliders (9) and (12) which hold the pencils.

The device, as shown in the drawing, is used for obtaining the *replotted range* and *azimuth* of the target from the *directing gun* of the battery when the azimuth of the target from the two ends of the *horizontal base* is known.

The surface of the celluloid takes a pencil mark readily, and it can be easily cleaned with a moistened rag or bit of waste dipped in powdered pumice.

The points (3), (4), and (5) represent the relative positions of the base ends and the gun; (4), the position of the gun, being at the center of the semi-circumference. The arms are of metal and are graduated to hundreds of yards. The slider on the middle arm carries a gearing which meshes on the rack cut on the edge of the arm, and, by means of the dial, which is divided into 100 equal parts, and the dial pointer, range readings to a yard can be made.

The distance between the axes of the pivots (15) and (16) is exactly the same as the distance between the axes of (3) and (4). Similarly, the distance (18) (19) is the same as (4) (5). In other words, in all positions of the middle arm the three arms will be parallel to each other.

The middle arm only is provided with an azimuth reading, the degrees being read on the semi-circumference and the minutes on the minute-dial on the arm.

The only adjustment necessary is to see that the azimuth reading is correct when the index (14) is made to coincide with the mark (24). If it is not, turn the minute-dial until the reading is correct.

To avoid the effects of any back lash in the gear of the minute-device, it will be advisable always to come up to the azimuth reading in the same direction.

To use the device, to replot from the base-end azimuths of the target: Set the middle arm to the *azimuth* of the target from the left-hand station (looking from the target) and move the slider of the left-hand arm along the arm, pressing down the pencil to mark the line joining this station and the target. Then set the middle arm to the *azimuth* of the target from the right-hand station, and make the pencil point of the slider on the right-hand arm mark a line crossing the first one drawn. The point of intersection of these lines will be the position of the target. Move the middle arm and its slider until the index of the latter can be placed at this intersection. The *range* and *azimuth* indicated by the dials on the middle arm will be the *replotted* range and azimuth of the target from the *directing gun.*

If the device is needed only to obtain the range and azimuth of the target from the *principal station* of the horizontal base, or is to be used in replotting for the *directing gun* from a *depression position-finder*, but two arms will be necessary. In the first case, the arm bearing the range and azimuth-dials will be pivoted at the point representing the principal station, which will be the center of the semi-circumference. In the second case, this arm will be pivoted at the point representing the gun, and the other arm at the point representing the position-finder station. The second arm, in the latter case, would be provided with a rack and range-dial like the first, but would not have the azimuth-dial.

RAFFERTY RELOCATOR.

(See Plates—Page XIII.)

[Plates VI and VII.]

When the two azimuths alone are used, the combination of the two azimuth instruments, the Relocator and the necessary communications constitute a Horizontal Position-Finder and Relocator.

It may be taken for granted throughout this description that the Relocator is placed in proximity to the gun.

The mathematical principles on which the instrument is based are the following:

1. Two angles and the included side of a triangle determine the triangle. (This *applies to* use as Hor. P. F.)

2. Two sides and the included angle of a triangle determine the triangle. (This applies to use with D. P. F.)

3. When any side of a triangle is oriented in azimuth the other sides are also oriented.

Figure 3, Plate VII, illustrates graphically these principles.

Horizontal base: Let *A B* be a horizontal base, *O* an object, and *G* a gun. The circles about *A* and *B* are azimuth circles, set so that the reading is zero when the telescope points south; the circle about *G* is the traverse circle which reads zero when the gun points south. The length and azimuth of *A B* are known; so also are the length and azimuth of *A G* and *B G*.

Through *O* draw a straight line parallel to *A B*, and on this, with *O* as a center, describe a semicircle *a'' c'' b''*, and produce *A O* and *B O* until they intersect this semicircle. If this semicircle be divided into degrees and minutes of azimuth, the reading at *a''* will be the azimuth of *A B*, because the diameter is parallel to *A B* and the reading where *B O* meets the circumference will be the azimuth of *B O*, where *A O* cuts it the azimuth of *A O*; similarly the reading where a line from any other point, as *G*, through *O* intersects the circle will be the azimuth of that line, as *G O*.

Parallel to *A B* draw *a' b'* so as to meet the prolongation of *A O* and *B O;* the two triangles *a' b' O* and *A B O* are similar, and if *a' b'* is made by scale to represent *A B*, *a' O* and *b' O* will, by the same scale, represent the length of *A O* and *B O*. Continuing, draw *b' g* parallel to *B G*, making it the proper length by scale; then *g O* will represent *G O* in length and direction.

The triangle *A B G* is a portion of the earth's surface; the triangle *a' b' g* is the same portion made to a scale. It is evident, therefore, that if any other point on the earth's surface within or without this triangle *A B G* be accurately located, it can be represented by a point in the triangle *a' b' g* or out of this triangle. So we might add another principle—if any line of a surface be oriented, that surface and every point on that surface will be oriented; and if any line of a surface be set in its correct position relative to any exterior point, all points of that surface will occupy their correct positions relative to the same point.

The rectangle about *A B G* is a surface; *A' B'* being another base line on that surface, it may be used instead of *A B*.

Vertical base: The same principles apply in this case, and they are illustrated by fig. 4, Plate VI.

In this case *A* is the Depression Position-Finder, *B* the gun; also, *A* is the Depression Position-Finder and *H* the gun.

The Relocator consists of a semi-circular board having parallel lines on its upper surface, as indicated in fig. 1, Plates VI and VII, a circular scale, *R*, the pivot *F*, of this circular scale, two arms *C* and *D* pivoted on *F*, the interior edges of which are lines passing through the center of *F*, and a spacer. Figs. 3, 5, and 5*A*, Plate VI, and figs. 2 and 4, Plate VII.

The circular scale *B* is a circular protractor on which the smallest division is ten minutes of arc, each degree from 0° to 360° being numbered, and the ten-minute divisions being numbered 10-20-30-40-50. These ten-minute divisions are indicated by diagonal lines which make together with the straight edges of *C* and *D* diagonal verniers; these enable an operator to set the arms *C* and *D* accurately to one minute of the arc or less, as shown in fig. 2, Plate VI. This protractor is attached to the board so that its reading at the parallel line through the center of the pivot shall be the azimuth of the base line. This orients the board. All the parallel lines then have the same azimuth as the base line.

The degree numbers on the circular scale are inside and outside, the two at one degree line differing by 180°; this gives a range in arc of 360°, or a complete circle.

The arms *C* and *D* are graduated so as to indicate ranges according to scale; the graduations are at the inner edges, the zero being at the center of the pivot *F*. Generally 200 yards to 1 inch is the scale, and readings by this can be had up to 10,000 yards.

Mounted on one of the arms, *C*, *D*, parallel and near to its inner edge, is a wooden bar of triangular cross-section; it is held in place by two small brackets. Each of the three faces of the bar is graduated with a scale of elevation; near the end of the face is the corresponding I. V., caliber of gun, and height above water. The scale allows also for jump, and for curvature of the earth. The I. V.'s on the three faces differ from each other by 10 f. s. Red figures indicate the time of flight on each face. This triangular scale is, therefore, a complete range-table, and is adjustable for the particular I. V.

The spacer is the base line in movable form: it has a vertical bar which is, by scale, the length of the base line; when placed in position on the board by means of the parallel lines, it has the direction and length of the base line, and in that way represents it in the solution of a triangle. Figs. 3, 5, and 5*A* show the form for use with D. P. F. Pins under the two vertical edges are useful when the arms *C* and *D* have almost the azimuth of the base line, and in other cases which will be noticed in practise.

Figs. 2 and 4, Plate VII, are the spacers which are used with a horizontal base.

Fig. 1, Plate VI, shows the spacer which is used with a horizontal base in position.

If a Relocator be made for one range-finder and gun, that is, if the parallel lines have the azimuth of *A B*, Fig. 4, the same relocator may be used at another gun, H; for this use there is required only a different spacer having a base to represent the parallelogram *A b H N;* when *A B* or *H N* is parallel to the lines, or, in other words, have their correct azimuth, *A H* will have its correct azimuth.

Similarly, if another range-finder than *A* be connected with *B*, its results can be transformed on the same Relocator.

It is evident that with one board, any number of bases may be used, and the change from one to the other is effected by means of different spacers. In all cases, the method of operating is the same.

If, in firing practise, points on the water be assumed for targets instead of visible targets, it is necessary to direct the telescope of the D. R. F. or the telescopes of the Hor. base in the proper direction to observe the splash. The gun must be aimed to avoid shipping, and after a clear field has been obtained, the azimuth of the line of fire will be known; also the approximate range. By setting *G* of the spacer at this point, bringing the spacer so as to secure parallelism to the base, then moving the arms to contact at *A* and *B*, fig. 1, Plate VII, the azimuth from each station to the splash can be given.

Practical operation, horizontal base (Plate VII): The azimuth of *O* from *A* is sent to a man at *G*, who sets one arm at this azimuth as indicated on the circular scale *R;* the azimuth of *O* from *B* is sent also to *G*, and the other arm is set at this azimuth; these two men hold fast their respective scale arms, *C* and *D*, while a third quickly moves the spacer, fig. 2 or fig. 4, between the arms and towards the pivot, until the vertical bar touches the arms; the proper edges of the base of the spacer are kept parallel to the parallel lines. The reading on the arms at *A* and *B* are the distances from *A* and *B* respectively. Then, holding the spacer in position, one arm is moved till its edge is over *G;* the reading on the arm at *G* is the distance from *G;* the reading on the circular scale *R* is the azimuth of *G O*.

To enable one man to do all the work, *C* and *D* are provided with clamps.

To bring the arm accurately to the position of *G*, an index pin is used; the pin is placed at *G*, the spacer removed and the arm brought to contact with the vertical edge of the index.

Vertical base (Plate VI): The range and azimuth are sent from *A* to *B;* a man sets one arm at the given azimuth, places the spacer with one edge at the given range and brings up the other arm against the other edge of the spacer; the base of the spacer must have its proper sides parallel to the parallel lines.

In use with horizontal base as well as with vertical base, the elevation is taken from the elevation scale instead of the range from the range arm.

On those instruments which are made for use as plotting boards, where extreme accuracy is desired, the arcs and pivot are made adjustable to allow for the expansion of the metal of the arcs. The middle segment of the arc is fastened to the board directly; the other segments are attached to slotted plates which are set into and screwed to the board; this attachment is by a screw and nut, the screw passing through the slot.

The pivot is movable for adjustment to correspond to this expansion.

Care, board: The board itself will be found to warp a little backwards and forwards. To keep it straight, it should be allowed to rest alternately on one side and the other. The convex side should be uppermost when the board is stored.

Arcs and arms: These are silver plated. When they become dark on account of handling and the oxidizing effects of the atmosphere, they can be cleaned as all silver is cleaned.

INSTRUMENT FOR OBSERVATION OF FIRE.

Designed by Board on Regulation of Coast Artillery Fire.

(See Plates—Pages XIV and XV.)

[Plate VIII.]

Nomenclature.

Fig. I. *Side elevation* of instrument on base plate.
Fig. II. *Rear elevation,* removed from base plate.
Fig. III. *Horizontal projection.*
Fig. IV. *Rear elevation of base plate.*

1. *Base plate.*
2. *Bracket* for opposing screws.
3. *Opposing screws,* which, when the instrument is in position, can be screwed up against the pin (6), thus securing the lower plate to the base plate.
4. *Lower plate,* the lower part of the outer cylinder of which is divided into thirty-six equal parts, or tens of degrees, every division being numbered. The upper part of this cylinder is cut for gearing with a worm screw.
5. *Female center,* attached to lower plate.
6. *Securing pin,* attached to lower plate.
7. *Upper plate,* carrying the index for the graduation on 4.
8. *Male center,* attached to upper plate.
9. *Nut,* screwed on the end of male center to retain the latter in contact with the female center.
10. *Milled head* of worm screw attached to upper plate. This screw meshes in the worm gear cut on the cylinder of 4.
11. *Gear wheel,* meshing in pinion on worm screw.
12. *Drum* on 11, for single degrees, divided into ten equal parts, each division numbered.
13. *Index* for 12.

14. *Vertical standards*, attached to the upper plate, and supporting the axle about whose axis (17) the telescope can be moved in elevation or depression, by turning 15.
15. *Milled head* of worm screw attached to 14.
16. *Vertical plate*, contained between the standards (14), terminating at its lower end in an arc centered at 17, on which a worm gear is cut, its upper end being attached to the lower bar (18).
17. *Axis* of the plate (16).
18. *Lower bar.* The rear end of this bar terminates in an arc on which a worm gear is cut, the arc having its center at 20.
19. *Upper bar*, carrying the Y's (26) and a worm screw working in the gear cut on 18.
20. *Vertical axis* about which the upper bar can be turned by means of 21.
21. *Milled head* of worm screw attached to the upper bar.
22. *Gear wheel*, meshing in pinion on worm screw.
23. *Drum* on 22, divided into 100 equal parts, each tenth division being numbered both ways from zero. Each division corresponds to one minute deviation right or left.
24. *Index* for 23.
25. *Pointer*, attached to 18, indicating the direction of the deviation.
26. *Y's*, secured to the upper bar, to which the telescope is attached.
27. *Micrometer box.*
28. *Graduated cylinder* of micrometer screw, divided into 100 equal parts, every tenth division being numbered. Each division corresponds to a vertical movement of the movable horizontal hair of one ten-thousandth of an inch, or to an angular movement of 1.86 seconds. A spiral groove is cut on the bottom of the cylinder (28) into which a tooth of the wheel (30) engages. This wheel connects by gearing with the register wheel (31), and in this way the number of complete revolutions of 28 is registered.
29. *Index* for 28.
30. *Toothed wheel*, operating register.
31. *Register wheel*, divided into 80 equal parts, every tenth division numbered each way from 0 to 40.
32. *Eyepiece.*
33. *Focusing screw.*

The telescope has a field of view of three degrees and thirty-four minutes, and a magnifying power of sixteen.

To set up the instrument: A foundation is first prepared by setting up on the concrete floor of the station, or on the superior slope of the parapet near the interior crest, a section of iron pipe (six to ten inches in diameter) of sufficient length to bring the eyepiece of the telescope, when in use, to a suitable height, filling the pipe with concrete to within about half an inch of the top, and leveling the surface carefully. Place the instrument, with base plate attached, on the concrete surface, set the azimuth reading for some datum point, and, without disturbing the azimuth setting, direct the telescope on the datum point. Mark the positions of the bevel-headed retaining screws underneath the base plate on the concrete surface. Remove the instrument from the base plate, replace the latter in the position marked and level it accurately by means of a hand level. Grout is then poured on the concrete surface underneath and around the plate and allowed to set. If care is exercised in this operation, the plate can be set sufficiently level for all practical work.

After the base plate has set firmly and it is desired to use the instrument, it is placed in position on the plate, set at the azimuth reading of any convenient datum point, and, by means of the opposing screws (3), the telescope is directed accurately on the datum point.

To use the instrument for the observation of fire: See that the index (24) and the index (29) are at zero. Direct and keep the line of collimation on the target by using the left hand on 15 and the right hand on 10. The instant the shot strikes, carry the left hand to the *top* milled head of the micrometer screw and the right hand to 21, and bring the vertical hair and the *movable* horizontal hair on the point of fall. The number of minutes deviation right or left can be read on the drum (23), and the number of divisions passed over by the zero of 28 can be read on 31 and 28. This latter number can be translated into yards over or short by means of a graphic table prepared for the height above mean low tide at which the instrument is used.

After noting these readings, set the index (24) and the index (29) *back* to zero.

When the instrument is removed from the base plate, the cylinder of the latter should be covered with the cap attached to it by a chain.

Plate IX shows a graphic table prepared for a height of instrument of 150 feet above mean low water.

Its construction and use should be apparent.

ANEMOMETER AND CLOCK.

(See Plates—Page XVI.)

[Plate X.]

Nomenclature.

1. *Hemispherical cups.*
2. *Radial arms.*
3. *Hollow conical spindle.*
4. *Metal or wooden staff,* to which 3 is attached.
5. *Set screw,* to secure 3 to 4.
6. *Binding posts* for wires running to clock.
7. *Case* inclosing gear wheel actuated by worm on a vertical rod to which the radial arms are attached.
8. *Clock.*
9. *Lever* attached to heart-shaped cam inside of clock, by means of which the pointer is thrown back to zero.
10. *Binding posts* for wires running to battery.
11. *Binding posts* for wires running from anemometer.
12. *Key* on arm of switch, by means of which, when the anemometer is switched off, the clock can be used as a stop watch.

The anemometer is of the usual form. The rod to which the radial arms supporting the hemispherical cups are secured meshes by worm gear with the wheel in the case (7). At every revolution of this wheel, corresponding to 25 revolutions of the cups, electrical contact is made.

The clock dial has two sets of graduations—the outer, for miles per hour; the inner, for seconds of time. The pointer can always be thrown back to zero by a light, quick stroke of the finger on the lever (9).

To set up the instrument: Secure the spindle (3) by means of the set screw (5) to a metal or wooden staff set up vertically on top of the station, or at some nearby place where the wind will have full play, and then secure the radial arms to the rod projecting up through 3 by a set screw not shown in the drawing.

Place the clock on a horizontal shelf in the station and make the wiring connections, as indicated.

When it is desired to use the clock in connection with the anemometer, see that the switch is thrown to the right against the stop. This will connect the clock with the anemometer and the battery. See that the pointer is at zero. When the first contact is made in 7, the clock will be started, and when the second contact is made, it will be stopped. The velocity of the wind in miles per hour will be found registered on the outer scale of the dial.

When it is desired to use the clock as a stop watch to determine time of flight, etc., throw switch to the left against the stop and that will cut off the anemometer, but will leave the clock connected with the battery. See that the pointer is at zero. The instant the gun is fired, press the key (12) to contact and release it. This will start the clock. When the shot strikes, press the key to contact again. The clock will be stopped and the number of seconds will be found registered on the inner scale.

TO DETERMINE THE WIND COMPONENTS.

(See Plates—Page XVII.)

[Plate XI.]

Figures 1 and 2 represent the device for this purpose.

A vertical rod, *P*, to which the vane *V* is securely attached, is furnished with a bevel-cog meshing with one of equal diameter on the horizontal shaft *H*, to which the disk *D* is fastened, so that a movement of *V* produces a corresponding movement of *D*, but in a contrary direction; hence the azimuth circle *R* must be numbered *contra-clockwise.*

The drawing indicates how the instrument is set up and secured. The gearing is protected from the weather by a box, provided with a door in front, which is secured against the outside face of the battery commander's station.

To adjust the instrument: Have the arrow on the disk set at the azimuth of some distant point which can be seen from the station, and held in position while the vane (its set screw having been loosened) is pointed directly away from that point, and then secured in position by the set screw.

To use the instrument: Ascertain the wind velocity from the anemometer, and the direction of the target from the directing gun from the replotter arm on the position-finder; move the arm *A* to read this azimuth and, from the point on its scale which indicates the observed wind velocity, read down to the arrow, guided by the nearest cross line, for the longitudinal component, and to the line at right angles to the arrow through the center, for the lateral component, being careful to observe the algebraic sign.

Thus in fig. 1, the azimuth from which the wind is blowing is 330 degrees; the azimuth of the target from the directing gun is 286 degrees; the wind velocity is 35 miles per hour; hence, the longitudinal component is plus 25 miles, and the lateral component is plus 24 miles. That is, the observed range must be *increased* by the difference corresponding to a 25-mile wind at that range, and the azimuth of laying must be *increased* by the number of minutes corresponding to a 24-mile wind at the observed range, in order to counteract the effect of the wind on the projectile.

INSTRUCTIONS FOR THE CARE AND PRESERVATION OF OPTICAL INSTRUMENTS.

It is essential, when circumstances will permit, that optical instruments should be kept in a warm, dry, clean store or box, or they will rapidly deteriorate. They should not be put away wet or damp, but be first carefully dried with a chamois leather. The lenses should be dried with a soft chamois leather or piece of silk, which must be carefully kept free of grit or dirt and must be used for no other purpose. If the lenses are simply dusty, the dust should be removed by a soft camel's-hair brush kept for that purpose.

Condensation of moisture will take place in the interior of a telescope and even between the lenses, although they may be in close contact, when the telescope is removed from a warm atmosphere to a cold one. From this cause and on account of dust and powder smoke being deposited on the glasses, it is necessary from time to time to clean the lenses.

When a telescope has been taken to pieces to clean the lenses, care must be taken to replace the glasses in the same order and in the same direction as when taken out, the curves of the surfaces being different. It is advisable to clean only one set at a time.

To clean the glasses, breathe on them and rub them gently with soft chamois leather or a piece of silk. If necessary, a little spirits of wine may be used.

The object glasses of telescopes and field glasses are made with two, very occasionally with three, lenses. The reason for this construction is to avoid the object viewed being seen with a fringe of color, and such lenses are called achromatic lenses. These lenses are composed of two kinds of glass, one crown glass, the other flint. Objects viewed through the flint glass are seen diminished. Those through the crown glass, magnified.

In some telescopes, the two glasses are cemented together with Canada balsam and fixed in a brass cell, which screws into the telescope tube; in others, the glasses are loose in the brass cell, secured by a screwed cap.

Usually the two surfaces of the lenses which face each other are ground to the same curve and are in close contact. In this case, the greatest care must be exercised in placing the proper surfaces together, or the glasses will be damaged, if not broken, and the telescope seriously affected. If one glass is gently pressed on the other, the surfaces with the same curve will be in such close contact that they will stick together.

The most convex side is placed outwards, that is, away from the eye, and the plano-concave or flint glass next.

If the glasses in the eyepiece are taken out singly, there will be no trouble in replacing them correctly.

To determine the power of a telescope, direct it on a brick wall about thirty yards off, focus it, and compare the number of bricks, as seen by the unaided eye, covered by the enlarged image seen through the telescope. Thus, if the enlarged image of a single brick seen through the telescope covers five bricks seen with the unaided eye, the power of the telescope is 5 to 1.

In the non-erecting eyepiece, add the focal length of the two lenses of the eyepiece, divide by two, and divide the focal length of the object glass by this quotient, to obtain the power of the telescope.

The focal length of a lens is obtained by measuring the distance from itself to the point at which the rays of the sun or some distant object are brought to a focus.

In ordinary telescopes, to replace broken glasses, if they are part of the object glass, the whole object glass should be sent to the maker; if one of the eyepiece glasses, then the whole eyepiece should be sent.

If the telescope is a small one and easily detached from its support, the whole telescope should be sent.

POWER AND ELECTRIC PLANTS FOR THE COAST ARTILLERY ARMAMENT.

At each artillery post there will be permanently installed a central power and electric plant of sufficient capacity to meet the needs of the armament.

The site chosen for the central station will be such as will afford the most complete protection from the fire of an enemy, and the wires carrying current from the station will be placed in deeply-laid under-ground conduits.

The station will consist of at least two large, well-ventilated rooms; one, called the *engine room*, will be equipped with an oil engine, dynamo, and switchboard, complete, together with the various instruments, materials, and tools necessary for their proper care and operation; the other, called the *battery room*, will contain the storage batteries and the metal tanks which hold the reserve supply of fuel oil for the engine. In case it is not practicable to obtain *running* water for cooling the combustion chamber of the engine, the tanks which contain the necessary water supply for this purpose will also be placed in the battery room. The floors of both rooms should be of Portland cement concrete and at least six inches thick, except those portions which constitute the foundations for the engine, dynamo, and storage tanks. These should be of a thickness proportional to the weight supported. Woodwork of every kind should be avoided as far as possible in the construction and equipment of the station. All exposed metal surfaces in the battery room will be kept covered with acid-proof paint.

Every wire leaving the station and before entering the under-ground conduit will be protected by a fuse within the engine room and will be provided with an efficient lightning arrester outside.

The Engine.

The oil engine selected for the plant must develop sufficient actual brake-horsepower, when running at normal speed, with full supply of oil to meet the *maximum* demand. The brake test should be made in the presence of an officer representing the Department before the engine leaves the manufacturer.

Great care will be taken in installing the engine. The foundation should be of the best Portland cement concrete, from 2 to 3½ feet thick, according to weight supported and slightly larger than the engine base. It should extend at least 1 foot above the floor of the engine room. The securing bolts will be put in place and the concrete allowed to properly set before the weight of the engine is permitted to rest upon it. Before securing the base to the foundation bolts, care will be taken to see that it is level, and that the axis of the drivers is parallel to the axis of the dynamo armature when the latter is in its proper position. Since the working temperature of the engine is very high, it is important to secure proper circulation of water in the jacket surrounding the combustion chamber.

This should be done whenever practicable by direct pipe connection to an established system of water supply, care being taken to so regulate the flow of water that its temperature on leaving the water jacket will not fall below 100° F. If the cooling is carried much below this point the engine becomes less efficient.

Where running water is not available, large storage tanks will be placed in the battery room for this purpose. The tank capacity should be about 65 gallons for each brake-horsepower. The water used in the tanks should contain no lime or salts, otherwise the deposits formed in the pipes and jacket will interfere with the circulation and may cause the engine to run hot.

Only high-grade refined petroleum (kerosene) of 150 degrees fire test will be used in the engine. The small tank which contains the immediate supply of oil should be so placed that the oil, in order to reach the vaporizer, must be forced in under considerable pressure, the top of the tank being always below the level of the inlet to the vaporizer. The pipe connecting the engine tank with the reserve supply of oil in the battery room will be provided with a double set of tightly-fitting valves, to guard against leakage.

The exhaust gases will be carried by a strong metal pipe to a silencing box outside the engine room, and thence by a vertical pipe of sufficient length directly into the air. All piping of every kind leading to or from the engine will be exposed and easy of access. The valves and joints will be tightly packed and kept free from leaks, and no oil, waste, or dirt will be allowed to remain in the vicinity of the engine.

No enlisted man will be permitted to take charge of an engine until he has been carefully instructed and understands thoroughly its construction, care, and operation.

The Dynamo.

The dynamo must be a direct current, compound machine, of sufficient electrical capacity to supply the maximum amount of current needed at any one time. Double connections will be provided on the terminal block, which will enable the operator to cut out the compound coils and run the dynamo as a simple shunt machine when charging the storage batteries. The field rheostat should have sufficient capacity and resistance to raise or lower the voltage twenty-five per cent, with constant armature speed.

The standard voltage for all plants will be 110; the amperage of the generator varying according to the energy required.

The dynamo should be mounted upon a substantial adjustable base of fireproof wood. The whole resting upon a foundation of Portland cement concrete which extends at least one foot above the floor of the engine room. Before securing the base to the foundation, the machine will be carefully leveled and the armature shaft in proper alignment. The pulley will be flanged, the face slightly crowned and the weight sufficient to act as an efficient fly wheel in securing an even speed of rotation. The distance between the center of the driver of the engine and the center of the dynamo pulley will be sufficiently great to obtain the proper amount of surface contact with the belt, to transmit the power without too great strain on the shaft. The commutator brushes should be of carbon, and of sufficient width and thickness to carry the maximum current without excessive heat or sparking. The design of the machine will be such as requires no shifting of the brushes, however much the load may vary. When not running, the brushes should be lifted out of contact with the commutator surface. The commutator should always be kept smooth and clean, but neither emery nor crocus cloth will ever be used for this purpose. If at any time the commutator becomes so rough or uneven from excessive sparking or other causes that the defects can not be remedied by the use of very fine sandpaper, the armature should be removed and the commutator turned smooth and true in a lathe. All wires leading from the dynamo will be carried directly from the terminal block to the ceiling overhead, where they will be firmly secured on separate insulators, and thence they will pass directly to the switchboard.

Especial care will be taken, when the dynamo is started for the first time, to see that the connections are properly made, the voltmeter and field rheostat in circuit, and the *main circuit open.* When it is known that the machine is generating properly, with desired polarity, and at the proper voltage, then the main line switch may be closed.

Portland cement concrete when damp is not a perfect non-conductor, and it is therefore important to have all wires carrying current inside the engine room heavily insulated and carried on independent insulators. No wire should be allowed to come in contact with any part of the dynamo frame, or with any other conducting substance in the room. Otherwise there will be a constant loss of energy through leakage.

The attendant in charge of the dynamo and switchboard must be a thoroughly competent and trustworthy man. He should be technically as well as practically familiar with every detail of the work.

The Switchboard.

The switchboard proper should consist of a single slab of marble or slate, four feet long, three feet wide, and three-fourths of an inch thick, resting upon two concrete pillars six inches in diameter and three feet high. When in place, the back of the board should be three feet from the side wall of the engine room and firmly secured thereto by iron rods. The wiring connections will all be made at the back. Each switchboard will have securely mounted upon it the following instruments:

One standard voltmeter (range 0 to 300 volts).
One standard ammeter (range 0 to 150 amperes).
One standard ammeter (range 0 to 50 amperes).
One automatic safety switch (overload), 150 ampere limit.
One automatic cut-out for charging battery (50 amperes).
One double-pole knife switch, for main circuit (150 amperes).
One double-pole knife switch, for battery circuit (50 amperes).
One double-pole, double-throw knife switch (150 amperes), for controlling outside circuit.
One field rheostat for the dynamo.
One voltmeter switch.
One pilot lamp.
Two lamp ground detectors.

Each instrument will be protected by a suitable fuse in circuit with it.

Wires leading to the different connections on the back of the board should drop to their proper places from insulators in the ceiling directly overhead.

Each connection should be numbered and its polarity indicated.

A complete diagram of the switchboard, showing the different instruments and their connections, with correct notation, will be posted in a conspicuous place near it.

Every wire leading to or from the switchboard will be thoroughly insulated.

Special Instruments, etc.

In addition to the regular equipment of the station, as indicated, the following special instruments will be provided with each central plant, viz:

One Wheatstone bridge testing set (with battery) (limits 0—1 megohm).
One magneto bell (testing).
One portable voltmeter, with double scale (0—10 volts and 0—150 volts).
One large size alcohol torch for soldering joints.
One complete set wiremen's tools:
    Climbers and straps.
    Eccentrics, with pulleys and cords.
    Splicing wrench for No. 4 wire.
    Pair flat pliers, 8 inches.
    Pair cutting pliers, 8 inches.
    Pair cutting pliers, 4 inches.
    Combination ratchet brace.
    One wire gauge.
    One steel measuring tape (100 feet).
One small power lathe, with complete equipment of tools.

CHARTS.

Fire commander's: Showing the fire area with coast and three and four fathom lines, graduations in azimuth, and positions of the fire commander's station, the position-finder stations, the different batteries, and the fire areas of the batteries.

To accompany this, a *book of ships* classified for attack, with photograph and drawings of the different classes showing dimensions, protection, armament, distinguishing marks, etc.

Battery commander's: Same as above with the addition of azimuth-difference circles, range-difference scale, and range-scale arm.

The *fire commander* having sent the azimuth and range of the *target*, the *battery commander* sets the range-scale at the approximate azimuth, runs out to the range, and takes the azimuth correction from the nearest azimuth-difference circle and the range correction from the range-difference scale, and applies these to the azimuth and range received. The *square system* may be used for indicating the target.

To accompany the chart: (*a*) drawings of the different classes of ships as for the fire commander; (*b*) attack sheets, which give the projectile when the class and range of ship are known.

Gun commander's difference-chart for each gun of a battery, except the *directing gun*, giving the azimuth and range corrections to be applied to the azimuth and range for the directing gun. It is the same in principle as the battery commander's chart.

DIFFERENCE CHARTS.

(See Plates—Page XVIII.)

A difference chart is a device by means of which, having the range and azimuth of a target from a point, as a position-finder or gun, the range and azimuth of the target from another point, or gun, can be found by applying a range and azimuth correction to the given range and azimuth.

It consists of :

(1) Azimuth-difference circles.
(2) A circle graduated in azimuth.
(3) A range-difference scale.
(4) A range-scale.

The method of using it is as follows: Set the range-scale at the approximate azimuth and run out on the scale to the range given; the azimuth correction with its proper sign will be found under the range, and the range correction with its proper sign will be found at the point where the range-scale crosses the range-difference scale.

To construct a chart: Let A be the point from which the range and azimuth are known, as for instance a position-finder, and B the point from which they are required, as for instance a gun. Five hundred yards to the inch is a convenient scale.

(1) At B and at the middle point of $A\,B$ erect perpendiculars; on the first perpendicular lay off the cotangents of the azimuth differences, and on the second the centers of the azimuth-difference circles. To construct any azimuth-difference circle, as for example the one for 5° 40′: from B lay off $B\,C$ equal to $A\,B$ cotan. 5° 40′, through the point C thus found and the points A and B pass a circle. The azimuth of any point on this circle measured from A will differ from that measured from B by 5° 40′, that is the azimuth difference for any point on this circle is constant; other difference circles for every two or four minutes are constructed in the same way.

(2) About A as a center describe a circle, and graduate it in azimuth, marking every five degrees.

(3) The range-difference scale is made by calculating the differences for three or more intermediate points, and completing the scale by interpolation. A mean range, four or five thousand yards, is used in the calculations; the differences will be approximately correct for the other ranges. The scale is placed along the azimuth circle, using another color to avoid confusion.

(4) The range-scale is pivoted at A and is graduated to every hundred yards.

PART IV.—DRILL.

GENERAL INSTRUCTIONS FOR DRILL AND PRACTISE.

DRILL.—The instructor will place himself where he can be seen and heard by all in the detachment. His explanations will be given with life, in a distinct voice, the tone of which should not be monotonous. He will take great pains to train the gun commanders and gunners to practise a good word of command, which should be quick and clear, but not louder than necessary.

The instructor will avoid uncommon expressions, long explanations, or details of manufacture. He will require each man to take by himself the position he is to occupy at any stage of the drill, and will, when necessary, illustrate how every operation in detail should be performed.

Endeavor should be made to interest men in their work, and to train them on such a system that they may thoroughly learn their duties with as little weariness to themselves, and as quickly as possible. It is desirable to get them, from the very commencement, to drill with precision and smartness, and without noise.

The drill should be varied by short descriptions of the equipment, ammunition, fuses, etc.

Alertness of attitude, smartness of movement, and *silence,* should be enforced throughout gun drill, as these indicate attention, fire discipline, and efficiency.

Detachments will, as soon as possible, be practised in actually loading and laying (or aiming) the gun as for service: dummy cartridges and projectiles of full weight are provided and issued for the purpose.

It is not necessary to instruct the detachment, especially when composed of recruits, in the exact order in which the drill is written. The instructor will use discretion in adopting a system by which the details of the drill can be readily taught.

On all occasions before giving a command, the gun commander will repeat the number of his gun.

At the command *take cover,* given at any time during drill or practise, all the numbers at the gun will lay down their equipments or implements, and take cover at double time.

At the command *stand fast,* the numbers will remain steady in the position they are then in, until *go on* is given.

When one number makes a mistake, the command *stand fast* should be given, and the error pointed out. When it can be avoided, the command *as you were* should not be given to the whole detachment, but only to the number or numbers concerned.

When a battery is to be manned, or when guns are to be used for drill, the *gun, position-finding, ammunition,* and *other details,* will be told off and marched to the battery.

Diminished numbers.—In the event of casualties, their places will be filled from the reserve. The possibility of the gun commander and gunner being disabled should be provided for, and their successors named. Drill with diminished numbers should, however, be practised; tables showing the duties of those numbers that remain will be found in the manual for each piece.

When practising at a moving target, where the elevating and traversing must be done simultaneously, and there are no reserves, it is advisable to diminish the number of guns in action and have them well served.

PRACTISE.--All parts of the guns and carriages, the equipments and implements, should be carefully examined to see that they are serviceable and in working order. In general, special attention is given to:

Elevating and traversing arrangements.

Arrangements for running to and from loading position.

Recoil cylinders, to see that they are filled with proper amount of liquid and the plugs properly inserted. A brass plate giving amount of liquid, and directions for filling and testing them, should be attached to the recoil cylinders of every mounting. Care must be taken that no air cushions are formed.

Sights and means of giving quadrant elevation, correct and in adjustment?

Sponge, of proper gauge?

Rammers, marked?

All hoisting gear and lifts, in working order?

Lamps, ready for lighting as required?

Where the elevation is given by device *other than the quadrant,* the *level of the traverse circle* should be tested at different points, so that due allowance may be made in practise for any want of level.

All instruments and appliances, such as position-finders, dials or other means of communicating ranges, telephones, etc., must be thoroughly examined and tested and, if necessary, adjusted.

All *tables, range tables* corrected for particular position of gun, etc., *charts,* etc., should be at hand and inspected to see if in good order.

Special points to be noted for each type of gun or mounting will be found in the manual for that gun.

General instructions for the guidance of those in charge of magazines or ammunition stores, and for the employment of lamps for lighting magazines and passages, will be found in "Magazines," Part II, and must be strictly adhered to.

The above preparations will always be necessary before practise, and will, as a rule, be carried out before the batteries or guns are manned.

Ordinary fire or *salvo fire* should be the general order of fire; *slow fire* either by single guns or by salvos being used for ranging only or for instructional practise. As much as possible of the service practise should be by *salvo fire,* as this is the order of fire that would be employed almost entirely in action.

CHARGE.—For practise, the cartridges of oldest date of manufacture will be expended first. In cases where the cartridges are of different lots of powder, with an insufficient number belonging to any lot, they will be blended.

Where powder is supplied in bulk, cartridges for practise will be made up by the batteries, and the necessity for mixing together powders of two or more different lots, when there is not enough of one lot, will always be insisted on.

However carefully it is kept, powder will generally be found not to give the initial velocity marked on the packages, and an allowance for this will be necessary.

Full and reduced charges will not be used in the same series. When reduced charges are necessary in combined practise, one or more batteries will be designated to use those charges.

PROJECTILE.—Before being inserted in the bore, projectiles will be carefully cleaned.

Shell in the shell room are, as a rule, filled but not fused. No more should be fused than are required for immediate use. If the shell are not filled, a similar rule will apply with regard to the number to be filled. Live shell are not to be fired with less than the authorized bursting charge.

Rapid-fire ammunition will be used strictly as service ammunition.

TIME FUSES.—Fuses from three to four years old burn slow and should be bored about 10 per cent. shorter than when new. The age of the fuse should be noted and those of one date selected for the practise, or at least for the same series.

LOADING.—Before giving the command *load*, the battery officer and gun commander will prescribe the projectile and the kind and length of the fuse. In the detail of general duties at the guns, the term *load* means the service of cartridge and projectile.

Attending the vent means:

(*a*) *With muzzle-loading guns*, removing the vent cover, clearing and closing the vent, and pricking the cartridge.

(*b*) *With breech-loading guns and mortars*, removing the old primer and clearing the vent. The old primer is removed before the breech-block is withdrawn. When necessary to use the punch, the gimlet, or the reamer to clear the vent, it will be introduced from the mushroom-head end of the vent. In all cases, care will be taken to avoid scoring the vent and the primer seat.

Ready means:

(*a*) *With radial-vented guns*, removing the priming wire and inserting the primer to which the lanyard is attached.

(*b*) *With axial-vented guns*, inserting the primer and attaching the lanyard.

(*c*) When *electric primers* are used, the wire left disconnected from the battery is joined up.

When carrying on practise with *breech-loading guns*, should circumstances not permit of a gun, loaded with a filled and *fused* shell, being fired at the end of a day's practise, the cartridge will be withdrawn and the shell left in the gun until a favorable opportunity offers of firing the round. On no account will an attempt be made to drive the shell back out of the gun. Before leaving the gun, the breech will be properly secured and such precautions taken as may be necessary until the round is fired. In case a projectile is not fused, the cartridge is withdrawn and the projectile driven back and withdrawn through the breech.

In the case of muzzle-loading guns, if it is not practicable to withdraw the charge, a priming wire will be left in the vent to indicate that the gun is loaded, and such other precautions taken as may be necessary.

MISSFIRES.—(*a*) *With radial-vented guns*, the proper number will prick the cartridge and insert a new primer, keeping well clear of the recoil. In case successive primers fail to ignite the charge, some fine powder should be poured down the vent.

(*b*) With *axial-vented guns*, if two or three primers fail to ignite the charge, the breech will be opened and the vent examined, *but under no circumstances should the breech be opened with a primer in the vent.*

(*c*) With *rapid-fire guns*, cartridges should be removed and safely disposed of. The breech will not be opened until after a sufficient delay to guard against a *hang-fire*, and then it should be opened carefully.

(*d*) When *firing by electricity*, in case of a missfire on contact being made, the primer and connections will be carefully examined. One wire from the firing battery will be disconnected before the primer is removed.

CEASE FIRING.—At the command *cease firing*, all primers will be removed from vents, except in case of axial-vented guns when the lanyard only is detached. When firing by electricity, *one wire* from the firing battery will be disconnected. With *rapid-fire guns*, the breech will be opened. With *machine guns*, the mechanism will be put to *safe*.

GENERAL DUTIES OF THE GUN COMMANDER AND GUNNER.

The *gun commander* commands the gun and is responsible to the battery commander for its regular and efficient service in all respects. The gun is never to be fired without his command, or until he has signalled that the gun is *ready* in case the firing is done by electricity from the battery commander's station.

At practise, he is responsible that the gunner identifies the target ordered, and knows the elevation and deflection, Case I; the deflection, Case II; or the azimuth, Case III; which are sent by the battery commander, according to the *case* employed. He reads and gives quadrant elevation to the elevating numbers when the latter can not from their position read it themselves. When time fuses are used, he bores or sets them.

When practicable, the gun commander should be in permanent charge of the gun, and responsible for its condition and cleanliness and for that of its emplacement, magazines, and storerooms; also, for all stores connected with the immediate service of the gun.

In exceptional cases, he may have to perform the duties of the battery officer.

The gunner's special duty is the *aiming* or *laying* of the gun. He will aim on that part of the target ordered by the battery commander, and in Case I, will direct both the elevating and traversing numbers by signal or otherwise. In the case of aiming for *direction* or in that of indirect laying, he will direct the traversing numbers only.

GUN COMMANDER'S AND GUNNER'S SIGNALS.

The commands or signals *elevate, depress, right,* or *left,* always refer to the direction of motion of the muzzle.

When elevation is given by the sight, the gunner gives verbal directions to the elevating numbers; when quadrant elevation is used and the elevating numbers can not, from their position, read the indicator, the gun commander commands *Elevate, Depress, Clamp,* or *Halt,* or signals as follows:

Elevate.—He holds up either hand, fingers pointing upward.

Depress.—He holds up either hand, fingers pointing downward.

Clamp or Halt.—He raises both hands, fingers closed.

For direction, the gunner commands *Right* (*or Left*), *Halt,* or signals as follows:

Right (*or Left*).—He motions with his right (or left) hand, his fingers pointing in the required direction.

Halt.—He raises both hands, fingers closed.

Where the elevation is indicated by means of a graduated arc on the carriage, the last motion should be in the direction of depression, in order to eliminate the effect of back-lash in the gear.

AIMING OR LAYING, AND FIRING.

Case I.—*Direction and elevation are given by the sight.*

The gun commander commands: *Aim,* announcing in a distinct tone the *deflection* and *elevation* ordered by the battery commander. The gunner sets his sight to the deflection and elevation ordered.

When firing at a *fixed target,* the gunner, after having aimed his gun, signals *ready* by holding his hand over his head; he and the traversing and elevating numbers then take cover.

The gun commander, when the signal *ready* is given, causes the battery officer and battery commander to be notified; he gives the command *No.* ——, *Fire,* upon receiving notification to that effect from the battery officer or the battery commander, as may have been agreed upon beforehand. Or, the gun may be fired by electricity from the battery commander's station.

When firing with *friction primers*, the firing number draws the lanyard taut as soon as the gunner is clear of the recoil, and fires at the command from his gun commander.

If there is any prolonged delay in firing the gun after it has been aimed, the firing number should be directed to slacken his lanyard, and the gunner, to verify or correct the aiming.

If the firing is done by electricity, one wire from the firing battery should be disconnected before the gunner goes to verify the aiming. The signal *ready* will be again given, as before.

When firing at a *moving target*, the elevating and traversing numbers remain at their posts. The gunner directs his gun on the target and keeps it aimed by giving the necessary directions to the elevating and traversing numbers. When satisfied that the gun is properly aimed, he signals *ready* and, if necessary, gets clear of the recoil. The gun commander gives the command to *fire* as soon as he sees the gunner's signal and that the latter is clear of the recoil. The firing number pulls the lanyard or presses the firing key at the command *Fire.* A signal that the gun is to be fired should be sent to the battery commander when the command to fire has been given.

If the carriage is provided with sighting steps or platform clear of the recoil, the *gunner may do the firing.*

Case II.—*Direction is given by the sight, and elevation, by the quadrant.*

The gunner adjusts his sight to the deflection ordered by the battery commander, and directs the traversing numbers only.

The gun commander directs the elevating numbers, and is responsible that the proper elevation is given.

Otherwise as in Case I.

In both Cases I and II with a *moving target*, the firing should be done at the gun and not from the battery commander's station, when the latter is at such a distance from the gun that the gunner's signals cannot be seen.

Case III.—*Direction is given by the azimuth arc on the traverse circle, and elevation, by quadrant.*

This *Case* will be used: (*a*) for predicted firing at a moving target; or, (*b*) when the position of a fixed target is known, but the target is not visible from the gun on account of smoke or other intervening obstacle.

The gun commander directs the elevating numbers and is responsible that the proper elevation is given. He is also responsible that the battery officer and battery commander are notified when the gun is laid, and, in predicted firing, unless the firing is done by electricity from the battery commander's station, that the gun is fired at the right instant.

The gunner directs the traversing numbers and, whenever practicable, causes them to set the gun at the approximate azimuth of the target while the gun is being loaded. He goes to the traverse circle and directs the setting of the gun at the final azimuth, which will be the final azimuth of the directing gun corrected for gun displacement when necessary, and then commands or signals *ready.*

The firing number pulls the lanyard or presses the firing key at the command No.——, Fire, from his gun commander, unless the gun is fired by electricity from the battery commander's station.

With *rapid-fire guns*, Case I will be used exclusively.

With *mortars*, Case III will be used exclusively.

Special instructions modifying or supplementing the above will be found in the manual for each particular type of gun or mounting.

To complete the chain of communication from the battery commander to the guns, it will be necessary to have a special detail at each gun consisting of:

One private, at the telephone;

One private, at the receiver of the dial-telegraph.

It will be the duty of the *telephone man* to put on the head-receiver as soon as he reaches his station, and to keep it on until authorized to remove it. He will be furnished with pad and pencil, and will keep a record of all important messages sent to or from the gun.

The *dial-telegraph man* will be provided with pad and pencil, and will keep a record in proper sequence of all messages appearing on the dials of his receiver.

In addition to the dial-telegraph and telephone, each gun will be provided with its range scale for which the elevation in degrees and minutes and the time of flight can be readily obtained for any range sent by the battery commander; and each gun, not the directing gun of the battery, will be provided with a difference chart by which the range and azimuth for the directing gun can be quickly transformed into the range and azimuth for the gun itself.

The gun commander operates the range scale and the difference chart. He first uses the difference chart to correct the range sent by the battery commander, if any appreciable correction is to be made, and then uses the range scale to transform this range into elevation. In Case I, he gives the sight elevation to the gunner to be applied to the sight; in Case II and Case III, he notes the quadrant elevation for his own use. In Case III, he also corrects the azimuth sent by the battery commander, when necessary, by means of the difference chart, and gives the correct azimuth to the gunner.

The battery officer and each gun commander will be provided with a list of code messages.

FORMATION OF THE BATTERY AND MARCHING MANEUVERS.

Coast artillery is habitually paraded, marched, and maneuvered as infantry, the formation and maneuvers being as prescribed in the Drill Regulations for that arm.

Infantry drills will be limited in number, and confined principally to recruits.

When a battery is formed on the *manning parade* for drill or practise as coast artillery, the following will obtain:

Formation of the Battery on the Manning Parade.

The battery is divided into detachments, the number corresponding to the number of guns assigned to it for service or drill. Each detachment consists of the *gun detachment proper, the ammunition detail*, such other *details* as are needed at the gun for its immediate service, and the *reserve*. *Special details* selected from the battery, such as the fire commander's and battery commander's, etc., will be assigned to the several detachments for formation and roll call.

Each detachment will be under the immediate command of its *gun commander*, who will at all times have a list of the men belonging to it and their specific duties as contained in the "Manning Table."

The detachment will form in two ranks, in the following order from right to left: gun detachment, ammunition detail, other details at the gun, reserve, and special details.

The *gun detachment* consists of the gun commander, gunner, and as many privates as are required for the immediate service of the gun; the *ammunition detail*, of the ammunition sergeant and the number of privates as laid down in the manual for the particular gun; *other details* at the gun, of two or more privates; *special details*, of the first sergeant and three or more privates; and *the reserve*, of the remaining men.

Absent gun-numbers and members of special details are replaced from the reserve.

Posts of officers, noncommissioned officers, and field music.

The *captain* is twelve yards in front of the center of the battery; the *lieutenants*, three yards in his rear in order of rank from right to left; and the *musicians*, three yards in rear of the lieutenants.

The *first sergeant* in line is two paces to the right of the front rank in line with it.

The *gun commanders* in line are on the right of their detachments.

The *ammunition sergeants* in line are two paces in rear of their details and act as guides of the detachments.

The *gunners* are the right files of the front rank of their detachments.

To form the battery.

At the sounding of the assembly, the first sergeant, with a copy of the Manning Table for the day, takes post on the manning parade about six paces in front of the center, facing the battery, and commands: 1. Fall in; 2. Call rolls; 3. Report.

At the command *fall in*, the gun commanders place themselves on the line, facing to the front, at sufficient distance apart for the formation of the detachments; the men of each detachment fall in on the left of their gun commander, in two ranks, facing to the front, the several details in relative order in the detachment as prescribed; the signal having ceased, the first sergeant causes the detachments to close to the right, if necessary.

At the command *call rolls*, the gun commanders step out two paces in front of the centers of their detachments, face toward them, call the rolls, and resume their places in ranks.

At the command *report*, the gun commanders stand fast, salute, and report, in succession from right to left, the result of their roll calls.

The first sergeant sees that absentees are replaced, faces about, and reports to the battery commander. The battery commander directs the first sergeant to take his post, gives his instructions, and commands: *Detachments and details to your posts.*

At this command, the battery officer proceeds to the battery; the special details fall out and report to the range officer, who sends them to their stations; each gun commander causes his detachment to *count fours* and marches it in *column of fours* to the rear of the gun emplacement, halts it, and commands: *Prepare for action* (*or drill*).

The *ammunition sergeant* conducts his *detail* to the magazine, sees that each member of it is informed as to his duties, inspects the magazine and lifts or cranes, etc., and prepares to supply ammunition.

The *special details* go at once to their posts, examine the instruments to which they are assigned, and make whatever adjustments may be necessary.

The *reserve* takes station under cover wherever directed.

The *gunner* forms the *gun detachment* and gives the command *Call off*, at which each number of the gun-detachment in succession, commencing with No. 1, calls in a distinct tone of voice the number of the post to which he has been assigned. He then directs the different numbers to bring up the stores and take post at the gun as prescribed in the manual for each type.

Each *gun commander* then commands *Examine gun*, which is executed as prescribed in the manual for the particular gun.

The gun commanders and the battery officer then make the inspection prescribed in "Manning a Fire Command," and the battery officer reports to the battery commander, who, in the mean time, has gone to his station.

At the close of the day's drill or practise, and on notification from the battery commander, the battery officer directs the gun commanders to replace stores and form detachments in rear.

Each gun commander gives the command: *Replace stores, form detachment;* sees that the stores are all replaced; that the gun, magazine, and storerooms are properly secured; and that the detachment forms in proper order in rear of the gun emplacement where it was halted preparatory to being sent to *posts*.

The battery officer, seeing all the detachments formed in rear of their gun emplacements, gives the command: *March off your detachments.* Each gun commander will then march his detachment in *column of fours* to the manning parade and dismiss it.

CEREMONY.

Inspection of a battery.

The battery will be paraded with the detachments and details at their stations as already prescribed, and *prepared for drill* (or action); detachments *at ease.*

The inspector, accompanied by the battery commander, will inspect the latter's station, the position-finder station, and then the guns, carriages, and magazines, usually in order from right to left.

As the inspector approaches the position-finder station, the officer or noncommissioned officer in charge will call the detail to attention, salute, and command: 1. Inspection; 2. Instruments. The instruments will be inspected, operated as may be required, and their working condition verified.

As the inspector approaches the guns, he will be met and saluted by the battery officer who will accompany the inspector during the inspection of the guns.

When the inspector arrives within ten paces of any gun, the gun commander commands: 1. Detachment, attention; 2. Prepare for inspection; 3. Open breech.

Having made the inspection of the gun, gun carriage, equipments, magazines, lifts, etc., the inspector proceeds to the next gun.

At the conclusion of the inspection, the officers will repair to their stations and the battery commander will execute such drill as the inspector may desire; or order that the battery be secured, the stations closed, and the detachments dismissed.

Inspection of a fire command.

The fire command will be paraded, with the batteries at the guns and stations as already prescribed, and *prepared for drill* (*or action*); batteries at ease. The inspector, accompanied by the fire commander, will first inspect the fire commander's station, and then the batteries in turn as laid down for the inspection of a battery.

Infantry inspections will be governed by the Infantry Drill Regulations.

CARE OF GUNS, POSITION-FINDERS, AND COMMUNICATIONS.

At all artillery posts and stations, the guns, position-finders, and communications, will be kept in perfect condition; the carriages, gears, ammunition lifts, trolleys, etc., clean and in smooth working order; and the platforms, magazines, ammunition, and stores, in good serviceable condition. These duties will have precedence over all other duty without exception.

Batteries will be marched daily (Sundays excepted) to the guns, and, under the supervision of a commissioned officer, will clean and place in order all the material connected with the guns, position-finders, magazines, communications, etc., and police the emplacements.

The regular Saturday and monthly inspections will be held with the organizations paraded at the guns of the artillery armament; this in addition to such infantry inspections as may be ordered.

At posts not garrisoned, if the carriages are to remain unused for short intervals of time, all bright and bearing parts should be covered with a thick coat of dense commercial cosmic; if the carriages are to remain unused for long intervals, the cosmic should be mixed with 25 per cent of resin. Cosmic only should be used on the screw threads of the breech mechanism, and a mixture of cosmic and resin in the bore. This mixture must be renewed from time to time. The rollers and roller paths should be cleaned and covered with cosmic. The space between the dust guard and the base ring should be filled with waste or oakum to keep out the dust. At intervals, the carriages should be traversed on the platforms. The habitual position of the gun is from battery. For repacking the cylinders, ¾-inch braided hemp packing soaked in oil and graphite will answer.

MANUAL FOR THE 8-INCH B. L. RIFLE.

[Mounted on U. S. Disappearing Carriage, Model 1894, in an emplacement not provided with ammunition lifts.]

GUN DETACHMENT.—Gun commander, gunner, and 10 cannoneers.

Name of detail.	Duties and posts.
Gun commander (sergeant).	Carries up range scale and difference chart, and places them on shelf or table near dial-telegraph or telephone. Post.—Two yards in rear of breech, facing it. (See "General Duties.")
Gunner (corporal or private duly qualified).	Carries up sight and places it on sight standard. Post.—Sighting platform. (See "General Duties.")
Breech detail (2 privates, Nos. 1 and 2).	Nos. 1 and 2 assist each other in putting on the sleeves; No. 1 carries up lanyard, chamber-sponge, prop, and water bucket containing water and hand-sponge, placing chamber-sponge on prop and lanyard and water bucket convenient to the breech. No. 2 equips himself with primer pouch, primer key and wire, places translating roller on loading-tray, carries them up, places the translating roller in position, and the loading-tray on loading platform convenient to the breech. Nos. 1 and 2 remove and replace breech-cover, open and close breech, insert and remove loading-tray, insert sections of cartridge and see that they are sent home, clean the bore, chamber, breech-box, breech-block, and assist in ramming the projectile. No. 2 serves vent; No. 1 fires. Posts.—Immediately in rear of breech, facing it, No. 1 on right.
Traversing detail (2 privates, Nos. 3 and 4).	Carry up the traversing cranks and place them on the traversing worm-shaft on their respective sides. Traverse the carriage. No. 4 attends to traverse crank clamp. Posts.—At traversing crank levers, in rear of lever, facing parapet, No. 3 on right.

GUN DETACHMENT—Continued.

Name of detail.	Duties and posts.
Elevating detail (2 privates, Nos. 5 and 6).	No. 5 carries up bore-sponge and prop. No. 6 carries up rammer and prop. Nos. 5 and 6 carry up the retraction ropes and place them on the loading platform out of the way; give the elevation. Posts.—At elevating wheels, facing carriage, No. 5 on right.
Charge detail (4 privates, Nos. 7, 8, 9, and 10).	Nos. 7 and 8 carry up the tripping bars and place them on the hooks on the chassis; No. 7 also takes up wrench for filling-plugs and places it convenient to his post; No. 9 takes up funnel and oil measure with oil for filling cylinders and places them near the parapet convenient to his post; Nos. 7 and 8 examine, and if necessary fill, the recoil cylinders, bring up the sections of the cartridge, attend to the tripping bars, and assist at the side levers when necessary; Nos. 9 and 10 remove and replace muzzle cover; No. 10 goes for projectile; No. 9 attends to sponge and rammer; Nos. 9 and 10 assist in ramming projectile, attend to side levers, and assist at the tripping bars. Posts.—Nos. 7 and 8 opposite the middle of the tripping bars, one yard outside the carriage, and facing it, No. 7 on the right; Nos. 9 and 10 opposite the muzzle, facing gun, and in line with Nos. 7 and 8, No. 9 on the right.

AMMUNITION DETAIL.—Ammunition sergeant and six privates.

Ammunition sergeant	Inspects cartridge room, shell room, platform crane; supervises attachment of pulley of hoist-tackle to eye of crane and sees that the tackle is in working order; fuses shell when required; and exercises general supervision over supply of ammunition.
Cartridge-room detail (1 private).	Uncases cartridges and places empty cases to one side.
Shell-room detail (2 privates).	Assist ammunition sergeant in fusing shell, and carry projectile to hoist detail.
Hoist detail (2 privates)	Run up pulley of hoist-tackle to platform detail; run down pulley after practise and replace tackle; receive projectile from shell-room detail and run it up to loading platform; run down empty shell tongs.
Platform detail (1 private).	Takes rope to loading platform and passes one end through eye of platform crane, passing the ends down to hoist detail; attaches pulley of hoist-tackle, when it is run up, to eye of platform crane and removes rope from the same, coiling it on platform or tying it to the rail; guides projectile on to shot truck; calls to hoist detail to lower away; releases shell tongs from projectile and passes them over rail to be lowered by hoist detail; uses rope to send down pulley of hoist-tackle, at the conclusion of drill or practise.

SPECIAL DETAIL AT GUN.—Telephone man. (See "General Duties.")

At the command *examine gun*, the breech and muzzle covers are removed, folded, and placed out of the way. The breech is opened and vent cleared; the bore, chamber, breech-box, breech-block, and breech mechanism, carefully inspected, the parts needing it thoroughly cleaned, and the breech closed after inspection; the recoil cylinders opened, examined, filled if necessary, and securely closed; the elevating and traversing gears tested; the azimuth indicator tested for adjustment; the level of the traverse circle tested; sight examined; the telephone and dial-telegraph tested.

At the command *load*, the breech is opened and vent cleared; breech-box and breech-block cleaned and oiled; loading-tray inserted; projectile brought up on truck and launched on loading-tray; truck removed; projectile rammed home; front section of cartridge inserted and pushed home with rammer; rear section of cartridge inserted and pushed forward by hand until its base barely clears the gas-check seat; loading-tray removed; breech closed; primer inserted and screwed well home; hook of lanyard inserted in eye of primer, or wires from firing battery connected up. Meanwhile the gun has been aimed or laid approximately during the loading. (See Cases I, II, and III, in "General Duties.")

After the gun is loaded, the gun commander commands: 1. Prepare to trip. 2. Trip. At the first command, the tripping bars are engaged against the lever ends of the pawls, and at the second command, the pawls are tripped.

For commands, etc., for firing, see "General Duties." The firing of the gun is done by No. 1 or the gunner.

To bring the gun from the firing to the loading position by means of the retraction tackle, the gun commander commands: 1. Rig the tackle. 2. Heave. 3. Halt, unreeve tackle. At the first command, Nos. 9 and 10 mount on the chassis, each carrying with him the hook end of the retraction rope belonging to his side, and engage the hooks in the eyes at the ends of the gun levers; Nos. 1 and 2 place a bight of the rope about the outer retraction sheaves on the chassis and pass up to Nos. 9 and 10 a bight to be placed about the outer retraction sheaves of the gun levers. The falls are similarly placed around the inner chassis retraction sheaves from below and reeved through the inner retraction sheaves on the gun levers from above, Nos. 1 and 2 carrying the falls inside the elevating arms, take four turns each around their respective drums, the standing part of each tackle being at the inner end of the corresponding drum and the first turn being taken over the drum. Nos. 1 and 2 take in the slack.

Nos. 3 and 4 transfer the cranks from the lower to the upper shaft. Nos. 3, 4, 5, 6, 7, and 8 man the cranks on their respective sides, Nos. 3 and 5 on the right, and Nos. 4 and 6 on the left, in rear of the cranks facing the parapet, No. 7 on the right and No. 8 on the left in front of the cranks facing from the parapet.

Nos. 9 and 10 stand by the side-levers.

The gunner throws the traversing worm-wheel out of gear by pulling the collar towards him.

At the second command, the numbers at the cranks turn them so that the upper half circle is described towards the parapet. As soon as the pawls engage, Nos. 9 and 10 work the side-levers until the gun is back to the loading position.

At the third command, Nos. 9 and 10 mount on the chassis, unreeve the tackle and pass the falls to Nos. 1 and 2, who coil them on the loading platform out of the way.

The gunner connects the traversing gear by moving the collar to the front.

The cannoneers resume their posts.

This maneuver should not as a rule be executed more than once at any one drill.

NOTES ON THE MANUAL.

The posts of the gun detachment as given above are for inspection and preparatory to the service of the gun.

The *gun commander* and *gunner* go wherever their presence is necessary.

The *reserve* is posted, for inspection, in two ranks, near the parapet on the left of the piece, facing from the parapet. At drill or practise, they will remain under cover wherever the gun commander may direct.

The *post of a cannoneer*, when once assigned in the "Manning Table," is not changed during the day's drill, unless for good and sufficient reasons; the men must be made proficient in the duties of the posts to which they are assigned. The assignments may be for the day, week, or month.

The *posts of absentees* from the gun detachment will be supplied from the reserve when there is one, and not from the gun detachment itself, unless it becomes necessary to drill with diminished numbers. When the detachment breaks ranks at the command *prepare for action* (*or drill*), the gun commander sees that the several numbers take the proper stores from the storeroom and place them as directed. If he thinks it necessary to carry up the armament chest to the gun platform, he so directs Nos. 5, 6, 7, and 8.

Duties of breech detail.—No. 2 removes the old primer, opens and closes the breech, and cleans the vent, seats and removes the loading-tray, helps to sponge the chamber and bore when cleaned; removes the pressure gauges and hands them to the gun commander, replacing them for the next round; helps ram projectile; inserts each section of cartridge, pushing rear section forward by hand so that its base barely clears the gas-check seat, it will then be pushed into place by the mushroom-head of the breech-block as the breech is closed, remaining in contact with it and facilitating the ignition of the charge; No. 2 inserts primer, screwing it well home, and attaches the hook of the lanyard to the eye of the primer.

No. 1 washes out the breech-box and breech-block with the hand-sponge, cleaning the gas-check seat and the sleeve as well as the mushroom-head, gas-check and block-threads; he wipes all the surfaces he has washed and oils the pad and threads of block and sleeve. If necessary to clean the chamber, he uses the chamber-sponge for that purpose before cleaning the breech-block, etc. If necessary to clean out the bore, No. 1 brings up the bore-sponge and inserts it, No. 9 brings up the extra joint and assists in screwing it on, and in taking it off as the sponge is withdrawn, replaces the extra joint and brings up chamber-sponge which he exchanges with No. 1 for the bore-sponge, replacing the latter on the prop. No. 1 replaces the chamber-sponge after using it, helps ram projectile, rams home front section of cartridge, and replaces rammer.

No. 1, after the breech is closed, prepares the lanyard, passes hook end to No. 2, and coils the lanyard in such a way that as the gun runs up to the firing position the lanyard will run off freely.

Elevating detail.—In changing the setting of the elevating gear, a strain must be placed on one or both of the hand-wheels in the direction of "Depress" on the elevation indicator before releasing the friction clamp, otherwise the elevating racks are liable to go down with a run, and cause injury. When this strain has been applied, No. 6 releases the friction clamp on his wheel by raising the handle to a vertical position. After the proper elevation has been secured and before letting go of the elevating hand-wheels, No. 6 engages the friction clamp on his wheel by lowering the lever to a horizontal position with his left hand.

Charge detail.—At the command *examine gun*, No. 7 takes a plug wrench and with No. 8 mounts on the chassis; they unscrew and take out the filling-plugs of both recoil cylinders and ascertain if they contain the proper amount of oil.

It is necessary that both cylinders be open when any filling is done, to avoid the formation of an air cushion. If the cylinders are not full, No. 7 calls to No. 9 for the funnel and oil measure, fills the cylinders and passes the funnel and measure back to No. 9, who replaces them. Nos. 7 and 8 then replace the filling-plugs, screwing them well home, and resume their posts, No. 7 replacing the wrench.

At the command *load*, Nos. 7 and 8 go to the magazine for the cartridge, No. 7 brings up the front and No. 8 the rear section. These sections are passed in succession to No. 2. Nos. 7 and 8 resume post and take down the tripping bars.

No. 9, after assisting No. 1 with the bore and chamber-sponge when necessary, takes the rammer to the breech and, as soon as the projectile has been brought up on its truck and placed in position for loading, places the rammer head against the base of the projectile, the staff in prolongation of the bore, and, assisted by Nos. 1 and 2, launches the projectile on the loading-tray; holds rammer out of the way until the truck has been removed and then replaces the rammer head against the base of the projectile, Nos. 1 and 9 on the right and Nos. 2 and 10 on the left; Nos. 1 and 2, nearest the breech, seize the staff handles on their respective sides, and at the command *ram* from No. 2, ram the projectile home with all force possible. Nos. 9 and 10 then quit rammer and resume posts.

No. 10 goes to the vicinity of the platform crane and brings the projectile on the truck to the rear of the breech, and chocks the wheels when the truck is in the proper position. As soon as the projectile has been launched on the loading tray, No. 10 unchocks wheels and runs the truck back to platform crane, returning immediately to assist in ramming.

In tripping the pawls, Nos. 7 and 8 engage the roughened ends of the tripping bars against the lever ends of the pawls by passing them through the screw-eyes as far as the stop-pins will permit. They stand between their bars and the parapet, facing to the rear, holding the bars near their ends, Nos. 9 and 10 standing inside of Nos. 7 and 8, and at the command *trip*, release the pawls by a quick hard jerk on each bar, and *hold them released* until the ratchets have passed below their upper ends. If the gun fails to run fully up to the firing position, Nos. 7 and 8, assisted by Nos. 9 and 10, force it up the remaining distance, using the tripping bars in connection with the fulcrums on the forward ends of the chassis rails and the ratchets under the outer clips of the top carriage.

Nos. 7 and 8 replace the tripping bars on their hooks and take cover.

A change of elevation can be effected at any time during the operation of loading, and the gun can be traversed at all times during this operation, *except* when the projectile is being launched from the truck to the loading-tray, and being rammed home.

The loading crane is not used, as the projectiles, when they are sent up from the lower level, are placed on trucks which can be adjusted to the prolongation of the bore when the gun is in the loading position.

The props for sponges and rammer are placed on the loading platform, on the opposite side of the breech from the platform crane used in hoisting the projectile. Provision will be made to have the sponges and rammer hung from a support outside of the rail.

MANUAL FOR THE 8-INCH B. L. RIFLE.

[Mounted on U. S. Disappearing Carriage, Model 1896, in an emplacement provided with ammunition lifts.]

The manual is the same as for the Model 1894, with the following exceptions and modifications:

Name of detail.	Duties and posts.
Elevating detail	There are no retraction ropes to be carried up.
Charge detail	Nos. 7 and 9 do not go for the sections of the cartridge, but take them from the truck when it is run up. No. 10 runs up the ammunition truck, with both cartridge and projectile on it, from the lift to the breech.
Ammunition sergeant	Inspects lift, etc., and does not supervise attachment of hoist-tackle, etc.
Cartridge-room detail	Places sections of cartridge on empty truck.
Shell-room detail	Run shell on trolley, over empty truck, lower it on truck, run trolley back to shell room.
Lift detail	Work ammunition lift; run loaded trucks on, and empty ones off, the lift.
Platform detail	Open and close doors to lift on level with loading platform, operate chock of lift, run empty trucks on lift, and signal hoist detail to lower away.

The gun is brought from the firing to the loading position by the same commands and means as in the 10-inch B. L. Rifle mounted on disappearing carriage, model 1896, substituting Nos. 9 and 10 for Nos. 11 and 12.

NOTES ON THE MANUAL.

The same remarks apply as for the Model 1894, except that No. 10 goes to the *ammunition lift* instead of to the *platform* crane.

MANUAL FOR THE 8-INCH B. L. RIFLE.

[Mounted on U. S. Barbette Carriage.]

GUN DETACHMENT.—Gun commander, gunner, and 10 cannoneers.

Name of detail.	Duties and posts.
Gun commander (sergeant).	Carries up range-scale and difference chart and places them on shelf or table near dial-telegraph or telephone. Post.—Two yards in rear of breech, facing it. (See "General Duties.")
Gunner (corporal or private duly qualified).	Carries up sight and places it in its seat. Post.—On the left of the gun commander. (See "General Duties.")
Breech detail (2 privates, Nos. 1 and 2).	Nos. 1 and 2 assist each other in putting on the sleeves. No. 1 carries up lanyard, chamber-sponge, prop, and water bucket containing water and hand-sponge, placing chamber-sponge on prop, and lanyard and water bucket convenient to the breech; assists in giving elevation. No. 2 equips himself with primer pouch, primer key and wire, places translating roller on loading-tray, carries them up, places the translating roller in position, and the loading-tray on loading platform convenient to the breech. Nos. 1 and 2 remove and replace breech-cover, open and close breech, insert and remove loading-tray, insert sections of cartridge and see that they are sent home, clean the bore, chamber, breech-box, breech-block, and ram the projectile. No. 2 serves vent; No. 1 fires. Posts.—On the loading platform, in rear of the breech, facing it, No. 1 on right.
Elevating detail (2 privates, Nos. 3 and 4).	No. 3 carries up bore-sponge and prop, and places them convenient, to the right and rear of the carriage; hands the bore-sponge to No. 1, and returns it. No. 4 carries up the rammer and prop, and places them to the left and rear of the carriage; hands the rammer to No. 2, and returns it. Nos. 3 and 4 man the crank handles of the shot-hoist lever, raise and lower it; give the elevation. Posts.—At elevating wheels, facing carriage, No. 3 on right.
Traversing detail (2 privates, Nos. 5 and 6).	Nos. 5 and 6 carry up the traversing cranks, and place them on the traversing worm-shaft, on their respective sides; traverse the carriage. No. 6 attends to the traverse crank clamp. No. 5 carries up wrench for filling plugs, and places it convenient to his post; No. 6 carries up funnel and oil measure with oil for filling cylinders, and places them near the parapet convenient to his post. Nos. 5 and 6 examine and if necessary fill the recoil cylinders; remove and replace muzzle cover. Posts.—Facing carriage, opposite traversing crank levers.

GUN DETACHMENT—Continued.

Name of detail.	Duties and posts.
Charge detail (4 privates, Nos. 7, 8, 9, and 10).	Nos. 7 and 8 go for sections of cartridge and hand them, at the proper time, to No. 2. No. 8 hands rammer to No. 2 for ramming cartridge, and replaces rammer. Nos. 9 and 10 place projectile on truck. No. 9 runs it to the shot-hoist lever, guides it so as to engage the shot-tray trunnions in their beds on the shot-hoist lever, and returns the truck. No. 10 takes rope to loading platform and passes one end through eye of platform crane, passing the ends down to hoist detail; attaches pulley of hoist-tackle, when it is run up, to eye of platform crane and removes rope, coiling it on platform or tying it round rail; guides projectile, when run up, over shot truck; calls to hoist detail to lower away; releases shell tongs from projectile, and passes them over rail to be lowered by hoist detail; uses rope to send down pulley of hoist-tackle at the conclusion of drill or practise. *When ammunition lifts* are provided, Nos. 9 and 10 *run off* loaded trucks; No. 10 *runs on* empty trucks, opens and shuts doors to lift, and operates chock of lift. Posts.—On gun platform, near the platform crane or the ammunition lift.

AMMUNITION DETAIL.—Ammunition sergeant and five privates.

Ammunition sergeant	Inspects cartridge room, shell room, and platform crane; supervises attachment of pulley of hoist-tackle to eye of crane and sees that the tackle is in working order; fuses shell when required; exercises general supervision over supply of ammunition. When ammunition lifts are provided, he inspects them, the shell tongs and the trolleys and omits that referring to platform crane, etc.
Cartridge-room detail (1 private).	Uncases cartridges and places empty cases to one side.
Shell-room detail (2 privates).	Assist ammunition sergeant in fusing shell; take projectile to hoist detail. When ammunition lifts are provided, they run a trolley, with empty shell tongs attached, over a projectile, pick it up in the shell tongs, run it out to the lift gallery, place it on an empty truck, and run the trolley back to the shell-room for another projectile.
Hoist detail (2 privates)	Run up pulley of hoist-tackle to platform detail; run down pulley after practise and replace tackle; receive projectile from shell-room detail and run it up to loading platform; run down empty shell tongs.
Lift detail (2 privates) [In place of hoist detail.]	When ammunition lifts are provided, they run empty trucks off the lift, and full ones on; operate the lift.

SPECIAL DETAIL AT GUN.—Telephone man. (See "General Duties.")

Examine gun.—The same as when mounted on disappearing carriage.

Load.—The same as when mounted on disappearing carriage, omitting the aiming or laying of the gun during *loading* and the tripping of the gun.

NOTES ON THE MANUAL.

The posts of the gun detachment as given above are for inspection, and preparatory to the service of the gun.

The *gun commander* and *gunner* go wherever their presence is necessary.

The *reserve* is posted, for inspection, in two ranks, near the parapet on the left of the piece and facing from the parapet. At drill or practise they will remain under cover wherever the gun commander may direct.

The *post of a cannoneer* when once assigned in the "Manning Table" is not changed, during the day's drill, unless for good and sufficient reason; the men must be made proficient in the duties of the posts to which they are assigned. The assignments may be for the day, week, or month.

The *posts of absentees* from the gun detachment must be supplied from the reserve when there is one, and not from the gun detachment itself, unless it becomes necessary to drill with diminished numbers. When the detachment breaks ranks at the command *prepare for action* (*or drill*), the gun commander sees that the several numbers take the proper stores from the storeroom. If he thinks it necessary to take up the armament chest to the gun platform, he so directs Nos. 5, 6, 7, and 8.

Duties of breech and elevating details.—No. 2 removes the old primer, opens and closes the breech, clears the vent, seats and removes the loading-tray, and helps to sponge the chamber and bore when cleaned; removes the pressure gauges and hands them to the gun commander, replacing them for the next round; helps ram projectile; inserts each section of cartridge, pushing rear section forward by hand so that its base barely clears the gas-check seat; it will then be pushed into place by the mushroom-head of the breech-block as the breech is closed, remaining in contact with it and facilitating the ignition of the charge. No. 2 inserts primer, screwing it well home, and attaches the hook of the lanyard to the eye of the primer. No. 2 assists in giving elevation.

No. 1 washes out the breech-box and breech-block with the hand-sponge, cleaning the gas-check seat and the sleeve as well as the mushroom-head, gas-check, and block-threads; he wipes all the surfaces he has washed, and oils the pad, and threads of block and sleeve. If necessary to clean the chamber, he uses the chamber-sponge for that purpose before cleaning the breech-block, etc. If necessary to clean out the bore, No. 3 hands the bore-sponge to No. 1 who inserts it; No. 3 brings up the extra joint and assists in screwing it on and in taking it off as the sponge is withdrawn, replaces the extra joint, and brings up chamber-sponge which he exchanges with No. 1 for the bore-sponge, replacing the latter on the prop. No. 1 replaces the chamber-sponge after using it. No. 1 helps ram projectile, rams home front section of cartridge, and returns rammer to No. 8 who replaces it.

No. 1, after the breech is closed, prepares the lanyard, and passes hook end to No. 2.

No. 4 takes the rammer to the breech, and, as soon as the projectile has been brought up on its truck and placed in position for loading, passes it to No. 2 who places the head against the base of the projectile, the staff in prolongation of the bore, and assisted by No. 1 launches the projectile on the loading-tray; No. 2 holds rammer out of the way until shot-hoist lever has been removed and then places again rammer head against the base of the projectile.

Nos. 1 and 2, at the command *ram* from No. 2, ram the projectile home with all force possible. Nos. 3 and 4 operate front elevating hand-wheels.

Traversing detail.—At the command *examine gun*, No. 5 takes a plug wrench and with No. 6 mounts on the chassis; they unscrew and take out both the filling-plugs of recoil cylinders and ascertain if they contain the proper amount of oil. It is necessary that both cylinders should be open when any filling is done, to avoid the formation of an air cushion. If the cylinders are not full, No. 6 gets the funnel and oil measure, fills the cylinders and replaces funnel. Nos. 5 and 6 then replace the filling-plugs, screwing them well home, and resume their posts, No. 5 replacing the wrench.

Charge detail.—At the command *load*, Nos. 7 and 8 go to the magazine (or ammunition lift) for the sections of the cartridge. No. 7 brings up the front, and No. 8 the rear section. These sections are passed in succession to No. 2.

Nos. 9 and 10 place projectile on truck, No. 9 running truck to the shot-hoist lever.

The gun can be traversed during all the operation of loading *except* when the projectile is being launched from the truck to the loading-tray.

MANUAL FOR THE 10-INCH B. L. RIFLE.

[Mounted on U. S. Disappearing Carriage, Model 1896, in an emplacement provided with ammunition lifts.]

GUN DETACHMENT.—Gun commander, gunner, and 12 cannoneers.

Name of detail.	Duties and posts.
Gun commander (sergeant).	Carries up range scale and difference chart and places them on shelf or table near dial-telegraph or telephone. Post.—Two yards in rear of breech, facing it. (See "General Duties.")
Gunner (corporal or private duly qualified).	Carries up sight and places it on sight standard. Post.—Sighting platform. (See "General Duties.")
Breech detail (4 privates, Nos. 1, 2, 3, and 4).	Nos. 1, 2, and 3 assist each other in putting on the sleeves. No. 1 carries up lanyard, chamber-sponge, and prop, and No. 3, two water buckets containing water and hand-sponge, placing chamber-sponge on prop, and lanyard and water buckets convenient to the breech. No. 2 equips himself with primer pouch, primer key, and wire, places translating roller on loading-tray, and with the assistance of No. 4, carries them up, places translating roller in position, and the loading-tray on loading platform convenient to breech. Nos. 1 and 2 remove and replace breech cover, open and close breech, insert and remove loading-tray, insert sections of cartridge and see that they are sent home. Nos. 1, 2, and 3 clean bore, chamber, breech-box, and breech-block. Nos. 1, 2, 3, and 4 assist in ramming projectile. No. 4 brings up and replaces sponge and rammer. No. 2 serves vent; No. 1 fires. Posts.—In line, immediately in rear of breech, facing it, and in the following order from left to right—Nos. 4, 2, 1, 3.
Elevating detail (2 privates, Nos. 5 and 6).	No. 5 carries up bore-sponge and prop; No. 6 carries up rammer and prop; and both give the elevation. Posts.—At the elevating hand-wheels, facing them, No. 5 on right, No. 6 on left.

GUN DETACHMENT—Continued.

Name of detail.	Duties and posts.
Traversing detail (2 privates, Nos. 7 and 8).	Carry up the traversing cranks and place them on the traversing worm-shaft on their respective sides; traverse the carriage—No. 8 attends to traverse crank clamp. Posts.—At the traversing cranks, in front of them, facing from the parapet, No. 7 on right, No. 8 on left.
Charge detail (4 privates, Nos. 9, 10, 11, and 12).	Nos. 9 and 10 carry up the tripping bars and place them on the hooks on the chassis. No. 9 also carries up funnel and oil measure containing oil for filling cylinders and places them near the parapet convenient to his post. No. 10 also carries up wrench for filling-plugs and places it convenient to his post. Nos. 11 and 12 carry up the retraction cranks and place them on the shafts. Nos. 9 and 10 examine, and if necessary fill the recoil cylinders; assist in ramming; hand sections of cartridge to Nos. 1 and 2; operate the tripping bars assisted by Nos. 11 and 12; assist at retraction cranks. Nos. 11 and 12 remove and replace muzzle cover; No. 11 passes funnel and oil measure up to No. 9 when called for, and replaces them. Nos. 11 and 12 bring up charge from ammunition lift on truck, assist in ramming projectile, replace truck, assist Nos. 9 and 10 at the tripping bars, operate reaction cranks assisted by Nos. 9 and 10. Posts.—Nos. 9 and 10 opposite the middle of the tripping bars, one yard outside carriage, facing it, No. 9 on right, No. 10 on left; Nos. 11 and 12 opposite the muzzle in loading position, facing gun, and in line with Nos. 9 and 10 respectively.

AMMUNITION DETAIL.—Ammunition sergeant and 8 privates.

Ammunition sergeant	Inspects cartridge room, shell room, ammunition lifts, shell-tongs, and trolleys; fuses shell, when required, and exercises general supervision over supply of ammunition.
Cartridge detail (2 privates).	Uncase cartridges and place sections on the shelves of truck; place empty cases to one side.
Shell-room detail (3 privates).	One of the detail assists the ammunition sergeant in fusing shell; the other two run a trolley, with empty shell-tongs attached, over a shell, pick it up in the shell-tongs, run it out to the lift gallery, place it on an empty truck, and run the trolley back to the shell-room for another projectile.
Lift detail (2 privates)	Run empty trucks off the lift and run on the full ones; operate the lift.
Platform detail (1 private)	Opens and shuts doors to lift; operates chock of lift; runs empty truck on lift.

SPECIAL DETAIL AT GUN.—See "General Duties."

At the command *examine gun*, the breech and muzzle covers are removed, folded, and placed out of the way The breech is opened and vent cleared; the bore, chamber, breech-box, breech-block, and breech mechanism carefully inspected, the parts needing it thoroughly cleaned, and the breech closed after inspection; the recoil cylinders opened, examined, filled if necessary, and securely closed; the elevating and traversing gears tested; the azimuth indicator tested for adjustment; the level of the traverse circle tested; the sight examined; the telephone and dial-telegraph tested.

At the command *load*, the breech is opened and vent cleared; breech-box and breech-block cleaned and oiled; loading-tray inserted; charge brought up on truck; projectile launched on loading-tray; truck removed; projectile rammed home; front section of cartridge inserted and pushed home with rammer; rear section of cartridge inserted and pushed forward by hand until its base barely clears the gas-check seat; loading-tray removed; breech closed; primer inserted and screwed well home; hook of lanyard inserted in eye of primer, or wires from firing battery connected up. Meanwhile the gun has been aimed or laid approximately during the loading. (See Cases I, II, and III in "General Duties.")

After the gun is loaded, the gun commander commands: 1. Prepare to trip. 2. Trip. At the first command, the tripping bars are engaged against the lever ends of the pawls, and at the second command, the pawls are tripped.

For commands, etc., for firing, see "General Duties." The firing of the gun is done by No. 1 or the gunner.

To bring the gun from the firing to the loading position, the gun commander commands: 1. Man the retraction gear. 2. Heave. 3. Halt. At the first command, Nos. 11 and 12 go to the retraction cranks. No. 11 operates the retaining pawl to permit the pulling out of the retraction chains which is done by Nos. 3, 4, 5, and 6, on their respective sides. Nos. 1 and 2 mount on the chassis and receive from Nos. 3 and 4 the ends of the chains, which they put on the hooks on the gun levers. No. 11 takes in the slack. Nos. 9, 10, 11, and 12 (assisted by Nos. 7 and 8 if necessary) take position at the retraction cranks, Nos. 9 and 10 on the outside, and at the second command, turn the cranks until the gun has been brought back to the loading position, when the gun commander gives the third command, and No. 11 lets out enough slack to enable Nos. 1 and 2 to take the ends of the chains off the lever hooks.

The cannoneers then resume their posts.

NOTES ON THE MANUAL.

The posts of the gun detachment as given above are for inspection, and preparatory to the service of the gun.

The gun commander and gunner go wherever their presence is necessary.

The *reserve* is posted, for inspection, in two ranks, near the parapet on the left of the piece, facing from the parapet. At drill or practise, they will remain under cover wherever the gun commander may direct.

The post of a cannoneer when once assigned in the "Manning Table," is not changed during the day's drill, unless for good and sufficient reason; the men must be made proficient in the duties of the posts to which they are assigned. The assignments may be for the day, week, or month.

The posts of absentees from the gun detachment will be supplied from the reserve when there is one, and not from the gun detachment itself, unless it becomes necessary to drill with diminished numbers.

When the detachment breaks ranks at the command *prepare for action* (*or drill*), the gun commander sees that the several numbers take the proper stores from the storeroom, and place them as directed.

Duties of breech detail.—No. 2 removes the old primer, opens and closes breech and clears the vent; assisted by No. 1, seats and removes the loading-tray, sponges chamber and bore when cleaned; removes the pressure gauges and hands them to the gun commander, replacing them for the next round; gives the commands for, and assists in, ramming projectile; inserts each section of the cartridge, pushing the rear section forward by hand so that its base barely clears the gas-check seat; it will then be pushed into place by the mushroom-head of the breech-block as the breech is closed, remaining in contact with it, and facilitating the ignition of the powder charge. No. 2 inserts primer, screwing it well home, and attaches the hook of the lanyard to the eye of the primer.

No. 1 assists No. 2 in opening and closing the breech, in seating and removing the loading-tray, and in sponging bore and chamber when the latter operation is necessary; assists in ramming projectile, and in sending sections of cartridge home; after the breech is closed, prepares lanyard, passing hook to No. 2, and coiling lanyard in such a way that as the gun runs up to the firing position the lanyard will run off freely.

No. 3 washes out the breech-box and breech-block with the hand-sponge, cleaning the gas-check seat and the sleeve, as well as the mushroom-head, gas-check, and block-threads; wipes all the surfaces he has washed, and oils the pad and threads of block and sleeve (or box); assists in ramming projectile.

When it is necessary to clean the bore and chamber, No. 4 brings up bore-sponge and assists Nos. 1 and 2 in sponging the bore; while the sponge is being withdrawn by Nos. 1 and 2, he brings up the chamber-sponge and exchanges it with No. 1 for the bore-sponge, which he replaces; he then brings up the rammer, exchanges it for the chamber-sponge, replaces the latter, and immediately returns to the rammer. If the piece is not to be loaded after the bore and chamber have been sponged, No. 4 does not bring up the rammer, but replaces the chamber-sponge. If the chamber and bore are not to be cleaned, just previous to loading, No. 4 brings up the rammer at once.

In ramming the projectile, Nos. 1, 2, 3, 4, 9, 10, 11, and 12, take hold of the rammer handles on their respective sides with the hand nearest to the rammer, Nos. 1 and 2 nearest the breech, Nos. 3 and 4 next, and so on, No. 1 placing the rammer head against the base of the projectile; at the command *ram*, given by No. 2, the projectile is forced into the chamber until its base is about thirty inches beyond the loading-tray; No. 2 commands 1. *Home;* 2. *Ram;* at the first command, all the numbers at the rammer take a firm hold; at the second command, all, working well together, send the projectile home with all force possible; all quit the rammer except Nos. 1 and 2, who withdraw it, No. 1 holding the head out of the way until the first section of the cartridge is inserted by No. 2, when he places the head against its base and, assisted by No. 2, pushes it home without unnecessary force, withdraws rammer and passes it to No. 4, who replaces it; No. 2 then inserts the rear section of cartridge and pushes it to its place as before described.

Elevating and traversing details remain at their posts during *examine gun* and *load* and carry out the instructions given for elevating and traversing.

Charge detail.—At the command *examine gun*, No. 9 takes a plug wrench and with No. 10 mounts on the chassis, unscrew and take out the filling-plugs of both recoil cylinders and ascertain if they contain the proper amount of oil. It is necessary that both cylinders should be opened when any filling is done, to avoid the formation of an air cushion. If the cylinders are not full, No. 9 calls to No. 11 for the funnel and oil measure, fills the cylinders and passes the funnel and measure back to No. 11, who replaces them; Nos. 9 and 10 then replace the filling-plugs, screwing them well home, and resume their posts, No. 9 replacing the wrench.

At the command *load*, Nos. 9 and 10 go to the breech and stand ready to assist in ramming; after the projectile has been sent home, each takes from the truck a section of the cartridge and stands ready to pass it to No. 2; after the sections of the cartridge have been taken by No. 2, Nos. 9 and 10 return to their posts and take down the tripping bars.

Nos. 11 and 12 go to the left, bring up truck with the charge on it, place it in proper position at the breech, chock the wheels, and take position at the rammer and assist in ramming; as soon as the sections of the cartridge have been removed from the truck, they unchock the wheels, take the truck back to the lift, resume their posts, and assist Nos. 9 and 10 in tripping the pawls.

In tripping the pawls, Nos. 9 and 10 engage the roughened ends of the tripping bars against the lever ends of the pawls by passing them through the screw-eyes as far as the stop-pins will permit. They stand between their bars and the parapet, facing to the rear, holding the bars near their ends, Nos. 11 and 12 standing inside of Nos. 9 and 10, and at the command *trip*, release the pawls by a quick hard jerk on each bar, and *hold them released* until the ratchets have passed below their upper ends. If the gun fails to run fully up to the firing position, Nos. 9 and 10, assisted by Nos. 11 and 12, force it up the remaining distance, using the tripping bars in connection with the fulcrums on the forward ends of the chassis rails and the ratchets under the outer clips of the top carriage. Nos. 9 and 10 replace the tripping bars and with Nos. 11 and 12 take cover.

A change of elevation can be effected at any time during the operation of loading, and the gun can be traversed at all times during this operation *except* when the projectile is being launched from the truck to the loading-tray and being rammed home.

The props for sponges and rammer are placed on the loading platform on the side of the breech opposite the ammunition lifts, so that the sponges and rammer will not be in the way of the trucks as they are run to and from the lifts. Provision will be made to have the sponges and rammer hung from a support outside the rail.

When the crusher gauge is used, the gas-check is covered with lubricant and the screw-thread painted with red lead.

MANUAL FOR 10-INCH B. L. RIFLE.

[Mounted on U. S. Disappearing Carriage, Model 1894, in an emplacement provided with ammunition lifts.]

The manual is the same as for the model 1896, with the following exceptions and modifications:

Name of detail.	Duties and posts.
Elevating detail	Nos. 5 and 6, in addition, carry up the retraction ropes and place them on the loading platform out of the way.

The gun is brought from the firing to the loading position and tripped by the same commands and means as in the 8-inch B. L. R. on disappearing carriage, model of 1894.

MANUAL FOR THE 12-INCH B. L. RIFLE.

[Mounted on U. S. Disappearing Carriage, Model of 1896, in an emplacement provided with ammunition lifts.]

The manual is the same as for the 10-inch B. L. Rifle, mounted on a disappearing carriage, model of 1896, with the addition of two supernumerary cannoneers to the gun detachment to assist in ramming the projectile; and of two *supernumeraries to the shell*-room detail to assist in handling the projectile.

REMARKS.

To open the breech: Release the rotating crank and turn it in the direction indicated by the "*open*" arrow till it brings up short, horizontal to the right, and is secured by its catch. Turn the translating crank briskly *contra-clockwise*, and the block slides back along the rails of the console. When the groove shoulders strike against the ends of these rails, the block stops short and the shock frees the console latch from its catch; now swing console and block back to the right of the gun till the securing latch engages in the catch. If, while the translating roller is turning, the latch of the console fails to work, it must be pushed into place by hand.

The gas-check of crusher gauge is covered with lubricant, and the screw-thread of gauge painted with red lead.

To close the breech, discharge the securing latch from its catch and swing console and block round to the left till the console abuts against, and is latched to, the breech face; turn the translating crank *clockwise* till it brings up, vertical, against the console. Release the rotating crank and turn it in the direction indicated by the "*close*" arrow till it brings up short, vertical, down, and is secured by its catch.

MANUAL FOR THE 12-INCH B. L. MORTAR.

[Spring-return carriage.]

GUN DETACHMENT.—Gun commander, gunner, and 10 cannoneers.

Name of detail.	Duties and posts.
Gun commander (sergeant).	The senior of each group brings up range scale and difference chart and places them on shelf or table near dial-telegraph or telephone. Post.—Two yards in rear of breech, facing it. (See "General Duties.")
Gunner (corporal or private duly qualified).	Brings up quadrant and places it convenient for the gun commander. Post.—On the left of the gun commander. (See "General Duties.")
Breech detail (4 privates, Nos. 1, 2, 3, and 4).	Nos. 1 and 2 assist each other in putting on the sleeves. No. 1 carries out lanyard, bore and chamber-sponge and prop, and No. 3, two water buckets containing water and hand-sponge, placing bore and chamber-sponge on prop, and lanyard and water buckets convenient to the breech. No. 2 equips himself with primer pouch, primer key, and wire; places translating roller on loading-tray, and with the assistance of No. 4, carries them out; places translating roller in position, and the loading-tray on mortar platform convenient to breech; Nos. 1 and 2 remove and replace breech cover, open and close breech, insert and remove loading-tray, insert cartridge. Nos. 1, 2, and 3 clean bore, chamber, breech-box, and breech-block. Nos. 1, 2, 3, and 4 assist in ramming projectile. No. 4 brings up and replaces sponge and rammer; mans and works the shell-hoist hand-wheel. No. 2 serves vent; No. 1 fires. Posts.—In line, immediately in rear of breech, facing it, and in the following order from left to right: Nos. 4, 2, 1, 3.

At the command *load*, Nos. 9 and 10
in ramming; after the projectile
a section of the cartridge and
of the cartridge have been ta
and take down the tripping
Nos. 11 and 12 go to the l
proper position at the bree
and assist in ramming; as
from the truck, they unc
their posts, and assist N
In tripping the pawl
bars against the lever
as far as the stop-pin
pet, facing to the r
inside of Nos. 9 a
hard jerk on each
their upper ends
and 10, assisted
tripping bars i
rails and the
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rammer and prop; assist in the elevation.

At the elevating hand-wheels, facing them, *No.* 6 on left.

Carry out the traversing cranks and place them on *the traversing* worm-shaft on their respective *sides; remove and* replace muzzle cover; exam*ine and if necessary* fill the recoil cylinders; go *for cartridge;* traverse the carriage. No. 8 at*tends to traverse* crank clamp.

For examining and filling the recoil cylinders, No. 7 *gets the wrench* for filling-plugs, and No. 8, *the funnel and* oil measure containing oil.

Posts.—*At the* traversing cranks, in front of them, *facing the* parapet, No. 7 on right.

Nos. 9 and 10 go for projectile, returning, so guide *the truck* as to engage the shell-tray trunnions in *their beds* in the shell-hoist scoop, which has been *suitably* lowered, and return truck.

Posts.—Convenient to the carriage, near the entrance to the magazine.

Ammunition Detail.—Ammunition sergeant and 5 privates.

Ammunition sergeant.—Inspects cartridge room, shell room, and shell tongs, and trolleys if any; fuses shell; and exercises general supervision over supply of ammunition.

Cartridge detail (2 privates).—Uncase cartridges; put empty cases to one side.

Shell-room detail (3 privates).—One of the detail assists the ammunition sergeant in fusing shell; the other two, assisted by Nos. 9 and 10, put shell in the shell-tray; or where trolleys are provided, run a trolley with empty shell-tongs attached over a shell, pick it up in shell-tongs, run it out to the end, and place it on the shell-tray, and run the trolley back to the shell room for another shell.

examine gun, the breech and muzzle covers are removed, out of the way; the breech is opened; the bore, chamber, and breech mechanism carefully inspected, the parts cleaned, and the breech closed after inspection; the recoil examined, and filled if necessary, and securely closed; the traversing gears tested; the azimuth indicator tested for adjust- the traverse circle tested; the telephone and dial-telegraph

load, the breech is opened and vent cleared; breech-box and and oiled; loading-tray inserted; charge brought up on on loading-tray and rammed home; truck removed; and pushed forward by hand until its base barely clears the loading-tray removed; breech closed; primer inserted and

well home; hook of lanyard inserted in eye of primer or wires from
ttery connected up. Meanwhile the mortar has been laid approxi-
during the loading.

NOTES ON THE MANUAL.

The posts of the gun detachment as given above are for inspection, and preparatory to the service of the gun.

The *gun commander* and *gunner* go wherever their presence is necessary.

The *reserve* is posted, for inspection, in two ranks, under cover in the gallery. At drill or practise, they will remain under cover wherever the battery officer or gun commander may direct.

The *post of a cannoneer*, when once assigned in the "Manning Table," is not changed during the day's drill, unless for good and sufficient reason; the men must be made proficient in the duties of the posts to which they have been assigned before any change of assignment is made. The assignments may be for the day, week, or month.

The *posts of absentees* from the gun detachment must be supplied from the reserve when there is one, and not from the gun detachment itself, unless it becomes necessary to drill with diminished numbers.

When the detachment breaks ranks at the command *prepare for action* (*or drill*), the gun commander sees that the several numbers take the proper stores from the storeroom and place them as directed.

Duties of breech detail.—No. 2 removes the old primer, opens and closes breech and clears the vent; assisted by No. 1, seats and removes the loading-tray, sponges chamber and bore when cleaned, removes pressure gauges and hands them to the gun commander, replacing them for the next round; gives the commands for, and assists in, ramming projectile; inserts cartridge, pushing it forward by hand so that its base barely clears the gas-check seat; it will then be pushed into place by the mushroom-head of the breech-block when the breech is closed, remaining in contact with, and facilitating the ignition of the powder charge. No. 2 inserts primer, screwing it well home, and attaches the hook of the lanyard to the eye of the primer.

No. 1 assists No. 2 in opening and closing the breech, in seating and removing the loading-tray, and in sponging bore and chamber when the latter operation is necessary; assists in ramming projectile, and in sending cartridge home; after the breech is closed, prepares lanyard, passing hook to No. 2.

No. 3 washes out the breech-box and breech-block with the hand sponge, cleaning thoroughly the gas-check seat and the sleeve, as well as the mushroom-head, gas check, and block-threads; wipes all the surfaces he has washed and oils the pad, and threads of block and sleeve (or box); assists in ramming projectile.

No. 4.—When it is necessary to clean the bore and chamber, No. 4 brings up bore and chamber-sponge and assists Nos. 1 and 2 in sponging, and afterwards replaces the sponge.

In ramming the projectile, Nos. 1, 2, 3, 4, 5, and 6, take hold of the rammer on their respective sides, Nos. 1 and 2 nearest the breech, Nos. 3 and 4 next, and so on; No. 1 places the rammer head against the base of the projectile; at the command *ram*, given by No. 2, the projectile is shoved forward into the chamber until its base is about 30 inches beyond the loading-tray; No. 2 commands 1. *Home;* 2. *Ram;* at the first command, all numbers at the rammer take a firm hold; at the second command, all, working well together, send the projectile home with all force possible; all quit the rammer except No. 6, who replaces it.

Elevating detail.—No. 6 brings up the rammer.

GUN DETACHMENT—Continued.

Name of detail.	Duties and posts.
Elevating detail (2 privates, Nos. 5 and 6).	Nos. 5 and 6 carry out rammer and prop; assist in ramming; and give the elevation. Posts.—At the elevating hand-wheels, facing them, No. 5 on right, No. 6 on left.
Traversing detail (2 privates, Nos. 7 and 8).	Carry out the traversing cranks and place them on the traversing worm-shaft on their respective sides; remove and replace muzzle cover; examine, and if necessary fill the recoil cylinders; go for cartridge; traverse the carriage. No. 8 attends to traverse crank clamp. For examining and filling the recoil cylinders, No. 7 gets the wrench for filling-plugs, and No. 8, the funnel and oil measure containing oil. Posts.—At the traversing cranks, in front of them, facing the parapet, No. 7 on right.
Charge detail (2 privates, Nos. 9 and 10).	Nos. 9 and 10 go for projectile, returning, so guide the truck as to engage the shell-tray trunnions in their beds in the shell-hoist scoop, which has been suitably lowered, and return truck. Posts.—Convenient to the carriage, near the entrance to the magazine.

AMMUNITION DETAIL.—Ammunition sergeant and 5 privates.

Ammunition sergeant	Inspects cartridge room, shell room, and shell tongs, and trolleys if any; fuses shell; and exercises general supervision over supply of ammunition.
Cartridge detail (2 privates).	Uncase cartridges; put empty cases to one side.
Shell-room detail (3 privates).	One of the detail assists the ammunition sergeant in fusing shell; the other two, assisted by Nos. 9 and 10, put shell in the shell-tray; or where trolleys are provided, run a trolley with empty shell-tongs attached over a shell, pick it up in shell-tongs, run it out to the end, and place it on the shell-tray, and run the trolley back to the shell room for another shell.

At the command *examine gun*, the breech and muzzle covers are removed, folded, and placed out of the way; the breech is opened; the bore, chamber, breech-box, breech-block, and breech mechanism carefully inspected, the parts needing it thoroughly cleaned, and the breech closed after inspection; the recoil cylinders opened, examined, and filled if necessary, and securely closed; the elevating and traversing gears tested; the azimuth indicator tested for adjustment; the level of the traverse circle tested; the telephone and dial-telegraph tested.

At the command *load*, the breech is opened and vent cleared; breech-box and breech-block cleaned and oiled; loading-tray inserted; charge brought up on truck; projectile launched on loading-tray and rammed home; truck removed; cartridge inserted and pushed forward by hand until its base barely clears the gas-check seat; loading-tray removed; breech closed; primer inserted and screwed well home; hook of lanyard inserted in eye of primer or wires from firing battery connected up. Meanwhile the mortar has been laid approximately during the loading.

NOTES ON THE MANUAL.

The posts of the gun detachment as given above are for inspection, and preparatory to the service of the gun.

The *gun commander* and *gunner* go wherever their presence is necessary.

The *reserve* is posted, for inspection, in two ranks, under cover in the gallery. At drill or practise, they will remain under cover wherever the battery officer or gun commander may direct.

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Duties of breech detail.—No. 2 removes the old primer, opens and closes breech and clears the vent; assisted by No. 1, seats and removes the loading-tray, sponges chamber and bore when cleaned, removes pressure gauges and hands them to the gun commander, replacing them for the next round; gives the commands for, and assists in, ramming projectile; inserts cartridge, pushing it forward by hand so that its base barely clears the gas-check seat; it will then be pushed into place by the mushroom-head of the breech-block when the breech is closed, remaining in contact with, and facilitating the ignition of the powder charge. No. 2 inserts primer, screwing it well home, and attaches the hook of the lanyard to the eye of the primer.

No. 1 assists No. 2 in opening and closing the breech, in seating and removing the loading-tray, and in sponging bore and chamber when the latter operation is necessary; assists in ramming projectile, and in sending cartridge home; after the breech is closed, prepares lanyard, passing hook to No. 2.

No. 3 washes out the breech-box and breech-block with the hand sponge, cleaning thoroughly the gas-check seat and the sleeve, as well as the mushroom-head, gas check, and block-threads; wipes all the surfaces he has washed and oils the pad, and threads of block and sleeve (or box); assists in ramming projectile.

No. 4.—When it is necessary to clean the bore and chamber, No. 4 brings up bore and chamber-sponge and assists Nos. 1 and 2 in sponging, and afterwards replaces the sponge.

In ramming the projectile, Nos. 1, 2, 3, 4, 5, and 6, take hold of the rammer on their respective sides, Nos. 1 and 2 nearest the breech, Nos. 3 and 4 next, and so on; No. 1 places the rammer head against the base of the projectile; at the command *ram*, given by No. 2, the projectile is shoved forward into the chamber until its base is about 30 inches beyond the loading-tray; No. 2 commands 1. *Home;* 2. *Ram;* at the first command, all numbers at the rammer take a firm hold; at the second command, all, working well together, send the projectile home with all force possible; all quit the rammer except No. 6, who replaces it.

Elevating detail.—No. 6 brings up the rammer.

Traversing detail.—At the command *examine gun,* No. 7 takes a plug wrench and, assisted by No. 8, unscrews and takes out the filling-plugs of both recoil cylinders, and ascertains if they contain the proper amount of oil. It is necessary that both cylinders should be open when any filling is done, to avoid the formation of an air cushion. If the cylinders are not full, No. 8 takes the funnel and oil measure, fills the cylinders, and returns the funnel and measure. Nos. 7 and 8 then replace the filling-plugs, screwing them well home, and resume their posts, No. 7 replacing the wrench.

At the command *load,* Nos. 7 and 8 go for the cartridge, and returning hand it at the proper time to Nos. 1 and 2, immediately thereafter manning the traverse crank-handles.

Charge detail.—At the command *load,* Nos. 9 and 10 go for the projectile.

REMARKS.

To open the breech.—The mortar must be in a horizontal position. Turn the rotating crank in the direction indicated by the "open" arrow till it brings up short, vertical down, and secured by its catch. Turn the translating crank briskly *contra-clockwise,* and the block slides back along the rails of the console. When the groove shoulders strike against the ends of these rails, the block stops short, and the shock frees the console latch from its catch; now swing console and block back to the right till the securing latch engages in the catch.

If while the translating roller is turning, the latch of the console fails to work, it must be pushed into place by hand.

The gas-check of crusher gauge is covered with lubricant, and the screw thread of gauge painted with red lead.

To close the breech.—Disengage the securing latch from its catch, and swing console and block around to the left until the console abuts against, and is latched to, the breech face; turn the translating crank *clockwise,* till it brings up vertical against the console.

Turn the rotating crank in the direction indicated by the "close" arrow till it brings up short, and secured by its catch.

MANUAL FOR POSITION-FINDERS.

EQUIPMENT OF A BATTERY DEPRESSION POSITION-FINDER STATION, TYPE A.

The *position-finding station* will be equipped as follows:

One Type A, D. P. F., completely installed.
One instrument for the observation of fire (on pedestal).
One (or more) telephones, with battery and switchboard.
One set of dial-telegraph, consisting of transmitting and receiving range dials, azimuth dials, and information dials.
One device for transforming range and azimuth from fire commander's station.
One stop watch.
One clock and bell, for marking time intervals.
One instrument for determining wind velocity.
One instrument for determining wind components.
One set of correction devices, for determining and applying correction for effects of tide, elevation, drift, atmosphere, etc.
One book of code messages.
One harbor chart, scale 400 yards to the inch.
One firing chart, same scale.
One set identification tables.

The following data will be prepared and posted in a conspicuous place near the position finder:

(1) Distance and azimuth to a number of fixed points in the harbor.
(2) Elevation of horizontal axis of instrument above mean low tide.
(3) Setting of tide-scale for different heights of tide.
(4) Distance and azimuth to the *directing gun of the battery*.
(5) Distance and azimuth to other P. F. stations.

Manning Detail.

In addition to the subaltern in charge, who is known as range officer (R. O.), the *manning detail* of each main position-finding station will consist of:

One non-commissioned officer or private who will act as observer.
One private (No. 1) at the replotter arm, assistant to observer.
One private (No. 2) at the telephone.
One private (No. 3) at the dial-telegraph.
One first sergeant (No. 4) who will note wind velocity, components, etc., and keep the station records.

As described in "General Duties of the Gun Commander and Gunner" (pages 76–77), there are three methods of directing the fire of coast artillery, designated Case I, Case II, and Case III. In all of these *Cases*, the range and azimuth of the target from the *directing gun of the battery* are determined at a battery commander's P. F. station; since, though in Cases I and II the gun is aimed in direction by means of the sight, the azimuth of the target from the gun must be known in order to determine the wind components, etc., and a knowledge of its approximate azimuth will enable the gunner to pick up the target more readily.

The nature of the operations at the P. F. station will, therefore, depend principally upon whether the target is fixed or moving, and the instructions will be arranged under these two subheads, taking each *Case* separately.

General duties at the battery commander's P. F. station. Battery commander.—Immediately on reaching his station, the battery commander examines the maps, charts, tables, etc., to ascertain if those needed for the day's work are on hand. He then establishes communication with the *battery officer*, from whom he receives a report of the result of the latter's inspection of the guns, etc., at the battery. He receives the report of the *range officer* as to the condition of the instruments at the station, lines of communication, etc., and then establishes communication with, and reports to the *fire commander* from whom he receives orders relating to target, projectile, and fire, and such other general or specific instructions as may be given.

He decides as to the order and rate of fire, and the character of the ammunition, and issues such orders to the *battery officer* and *range officer* as may be necessary to insure *full* compliance with the instructions of the *fire commander*.

He determines and applies the corrections to the replotted range and azimuth for the *directing gun of the battery*, and sees that the correct data, according to the *Case* employed, is sent to the guns by telephone and dial-telegraph.

When he has received notification that the gun or guns have been properly aimed or laid, he gives the order to fire, or closes the firing circuit himself.

He observes the fire.

He sees that the instructions contained in "Precautions for Safety" at practise are strictly carried out.

Range officer.—The range officer, having conducted his detail to the station, makes a careful inspection of the equipment, sees that the bearings of the position-finders are properly cleaned, oiled, and that the parts work smoothly;

supervises their adjustment for level, tide, range, azimuth, and refraction; and verifies the readings, taken by the observer on the datum points, for range and azimuth. He examines and tests the working of the dial-telegraph to see that the contacts and switches are in proper condition, and that all the dials return to zero when the synchronizing key of each transmitter is pressed down. He examines and tests the telephones, call-bells, clock, stop watch, and the devices for indicating the velocity and direction of the wind. He reports the results of his examination to the battery commander.

During the firing, he superintends the work of the observer and of Nos. 1, 2, 3, and 4, correcting mistakes, noting adjustment of instruments, and assisting in the work of the station whenever necessary.

He assists the battery commander in determining the corrections to be applied, and in his absence from the station, carries out such instructions as he may receive.

At the close of the day's firing, he inspects the equipment, and reports to the battery commander, handing him all records connected with the day's work at the station.

He sees that the instruments are properly secured and covered, and that all electrical circuits are left *open*. Before leaving the station, he sees that the windows are securely fastened and the door locked. The key remains in his possession or is turned over to the battery commander.

Observer.—The observer is selected on account of special aptitude, and must understand the principles of construction and use of the instrument in order to be qualified for the duty. He is responsible for the care of the position-finding instruments at all times, and will report deficiencies, defects, or accidental damages, to the range officer, as soon as they are known. Under the supervision of the range officer, he adjusts the instruments, verifying the adjustment from time to time by sighting on some one or more of the datum points, noting the condition of the tide and making the necessary scale adjustment.

His post during firing is at the telescope of his instrument, and he must be careful to see that no one leans on the table or touches it unnecessarily.

When assigned a target, he immediately turns the training crank of the position-finder with his left hand and the range crank with right hand until the vertical cross-wire is on the target and the horizontal wire is in exact coincidence with its water line, and keeps on the target by turning the cranks in the proper direction and with the proper rate of motion. He calls out to No. 1 the range indicated by the range dial of the position-finder. His duties in *predicted firing* will be described under that head.

No. 1.—The post of No. 1 is at the replotter arm of the position-finder. In performing his duties, he will be careful not to lean upon the table of the instrument, nor to touch it unnecessarily.

As soon as the observer has called out the range of the target, No. 1 slides the pointer along the scale-arm until the index shows that range; brings the replotter-arm quickly but gently into contact with the pointer, and slides the index of the arm until exactly opposite the point of contact; reads the range in yards *from the gun* on the index-dial, and the *azimuth from the gun* in degrees and minutes of arc on the azimuth dials, of the replotter arm.

His duties in *predicted firing* will be described under that head.

No. 2.—No. 2 takes post at the telephone, ready to answer calls and to transmit and receive messages. He is provided with pencil and pad, and when so directed, he keeps a record of all important messages sent or received.

During the firing, he keeps the receiver constantly at his ear; receives the corrected data for the *directing gun* of the battery from the battery commander, or range officer; and transmits the same slowly and distinctly to the guns.

He promptly informs the battery commander of calls and messages from other stations; is responsible to the range officer for the care of the telephones, batteries, call-bells, and telephone switchboard; and should be selected for his aptitude in the use of the telephone.

No. 3.—No. 3, operates the dial-telegraph instruments; he must be thoroughly instructed as to their mechanical and electrical construction, and capable of making the necessary tests and adjustments.

He receives from No. 4 the written data for the *directing gun* of the battery, transmits it, and files it in the order received upon the day's file. Each time before sending data, he presses the synchronizing key on the right of each transmitter key-board, to restore the number-dials to zero, and then proceeds as before.

On receiving from the battery commander the particular information relating to aiming or laying, ammunition, fire, target, etc., which is to be sent to the guns by dial, No. 3 presses the proper key of the information dial key-board and the required signal is sent. In case a code message is to be sent, No. 3 presses the "code" key and the word "code" appears on the information dial at each gun. The proper *code numbers* are then sent by the *range-dials.*

He is responsible for the care of all the dial-telegraph instruments of the battery, and will make frequent and careful tests of the electrical connections, examining contacts, switch-board, etc.

No. 4.—No. 4 keeps the official records of the station, and is provided with pencil, paper, and the necessary printed forms which he fills out in accordance with the instructions thereon.

He reads and records the *wind velocity, direction,* and *components,* and determines such other *atmospheric data* as may be required. He writes on a slip of paper the corrected data for the *directing gun* of the battery, as soon as it has been determined and *announced* by the battery commander, and hands it to No. 3 for transmission to the guns.

He will be careful not to interfere with the other numbers in the performance of their duties.

INSTRUCTIONS FOR DRILL OR PRACTISE.

Fixed Target.—For all Cases.

Battery commander.—Verifies target taken by observer, and indicates point on target to be aimed at; sees that replotted range and azimuth are sent to the guns; determines and applies corrections to replotted range and azimuth for directing gun. announces corrected range *in yards,* and deflection *in minutes,* in Cases I and II, and corrected range *in yards* and azimuth *in degrees and minutes* in Case III; sees that the corrected data is sent to the guns; receives notification that guns are *ready* and gives orders for firing or closes firing circuit himself; observes fire and notes errors in range and direction.

Range officer.—Assists battery commander.

Observer.—Directs telescope on target, the vertical cross-wire being placed on the point of the target indicated by the battery commander; calls to No. 1 the range of target; when shot strikes water, directs telescope on the splash and calls to No. 1 the range of splash; after No. 1 has replotted splash and called out range and azimuth, directs telescope on target again and calls to No. 1 range of target; and continues in this manner until the close of the firing.

No. 1.—Operates replotter arm as soon as observer calls out *range;* calls out *replotted range* and *azimuth* of target; moves replotter arm out of the way; does similarly for the splash, and so continues.

Nos. 2, 3, and 4.—Duties as given in "General Duties."

Moving Targets.—Case I and Case II.

Battery commander.—Verifies target taken by observer; sends word to the guns on what part of target to aim, also the approximate replotted range and azimuth, and direction of motion of the target with reference to directing gun; determines the deflection to be applied to the sight, and the correction to be made in the range; sees that the correct data is sent to the guns, and gives the order to *commence firing;* observes the fire and notes errors of range and direction.

Range officer.—Assists the battery commander.

Observer.—Directs telescope on target as ordered by battery commander and follows it; stops the telescope at the word from the battery commander and calls range to No. 1; as soon as No. 1 has called out replotted range and azimuth, picks up target again and follows it, stopping again when directed to do so, and so continues. He makes no observation of fire unless specially directed.

No. 1.—Is provided with pencil and pad. He operates the replotter arm whenever the observer calls range to him; calls out and notes the *replotted range and azimuth;* moves the replotter arm out of the way. The battery commander, having caused the observations on the target to be made at some convenient interval of time, can make use of the notes taken by No. 1 in ascertaining the *angular rate of motion* of the target and the *rate of change* in its range, and can thus determine the proper corrections for travel.

Nos. 2, 3, and 4.—Duties as given in "General Duties."

Case III.—Predicted firing at a moving target.

The electric clock in the station can be regulated to some convenient constant interval of time, say twenty or thirty seconds, and the gong bell marks this interval. At five seconds before the instant for observation, the bell buzzes; at two seconds before, one second before, and at the instant for observation the bell gives a single stroke. This third stroke is the signal for arresting the motion of the telescope which has been kept following the moving target.

Battery commander.—Verifies the target taken by the observer and tells him on what part of it to sight; when ready to commence observations, directs the range officer to start the clock and causes two observations on the target to be taken, from which he ascertains the *rate of change* in range and direction of the target from the position-finder. He then decides at what interval of time from the first observation he will fire, taking into consideration the length of time necessary to prepare the guns for firing.

By applying the *amount of change* in range and direction to the first position of the target with reference to the position-finder for this interval, he predicts the position of the target at the expiration of that time; has the position-finder set for it, and the *replotted* range and azimuth determined and sent to the guns, which are laid accordingly. He then determines the deflection corrections to be applied to the azimuth of the predicted position from the position-finder, including the change due to travel of target, also the range corrections for the *directing gun.* The corrected range is sent to the guns and the azimuth corrections applied to the position-finder, and when the image of the target touches the vertical hair of the telescope, the guns, if reported ready, are fired.

This method is equivalent to *direct aiming* for direction, and success in its application will depend on the amount of preliminary practise bestowed upon it, assuming that the triangulation has established accurately the relative positions of the guns with respect to the location of position-finders and all other points in the field of fire.

Range officer.—Assists the battery commander.

Observer.—Directs his telescope on the target as ordered by the battery commander, and follows it until he hears the *first signal for observation*, when he stops the telescope; calls out *range* and *azimuth* to No. 1, who notes them; picks up target again, stops the telescope at the *second signal for observation*, and calls out range and azimuth to No. 1; sets the telescope for the *azimuth* of the position predicted by the battery commander, or follows whatever instructions he may receive from the latter.

No. 1.—Is provided with pad and pencil. He notes the *range* and *azimuth* called by the observer for the *first* and *second* positions of the target; determines the *rate of change* in range and direction, and informs the battery commander of the result. When the telescope is set for the predicted position, he moves the range index of the *position-finder* to the predicted range and operates the replotter arm, calling out the *replotted* range and azimuth of the predicted position, and carries out whatever other special instructions may be given him.

Nos. 2, 3, and 4.—Duties as previously described.

HORIZONTAL-BASE POSITION-FINDER.

Two stations are necessary; one the battery commander's station, the other the secondary station.

In addition to the equipment as described for the *battery commander's depression position-finder station*, there will be required a *dial-telegraph* transmitter and receiver, *for azimuth angles only*, connecting with the secondary station; a *replotting device;* the *Type B* instrument to take the place of *Type A*.

The *secondary station* will be equipped with:

(1) An *azimuth instrument.*

(2) A *telephone* connected with the principal station and with the guns.

(3) A *dial-telegraph* transmitter and receiver, *for azimuth angles only*, connected with the principal station, and so connected with the azimuth receivers at the guns that it can be switched on when necessary.

(Since the first figure of a number expressing degrees of azimuth exceeding 99° will never be greater than 3, there will remain 6 keys of the left-hand dial which can be utilized for *information* signals. One of these will be *code*, and when this appears on the receiver, the operator will know that the figures sent on the other dials constitute a code message. If necessary to send range as well as azimuth to the secondary station to enable the observer to identify his target, the word *range* will be sent on the left-hand dial and the range on the other four; and similarly for other information.)

(4) A *bell* connected with the clock in principal station.

(5) A *list of azimuths and distances* from the secondary station to various fixed points and buoys in the harbor.

(6) A *set of identification tables.*

(7) A *list of code signals.*

Manning details.

For the principal station:

The same as in the case of a D. P. F.

For the *secondary station:*

One observer, who also operates the dial-telegraph.

One private, to operate the telephone.

The general duties of the detail at the principal station are practically as described in "General Duties" at the D. P. F. station, except that the observer does not call the *range* unless specially directed, but calls the *azimuth* of the several observations. No. 1, instead of operating the replotter arm of a *Type A, D. P. F.*, operates the replotting device, and the dial-telegraph connecting with the secondary station.

At the latter station, the observer is responsible for the condition and adjustment of the instruments, and for the condition of the equipment. As soon as the detail has taken post the observer will make inspection of the station, and report the result to the battery commander. He will make a similar inspection and report at the close of the day's work, and will turn in the day's records, as may be directed.

He sees that everything is secure before leaving the station, locks the door, and turns the key over to the battery commander, range officer, or other person authorized to receive it.

INSTRUCTIONS FOR DRILL OR PRACTISE.

Fixed target.—For all cases.

Battery commander.—When the target has been assigned by the *fire commander* and identified by the *battery commander*, the latter causes the observer at his station to ascertain its *azimuth* and *approximate range*, and No. 1 to ascertain, by means of the replotting device, its *approximate range* and *azimuth* from the secondary station. He sees that this information, together with a description of the target and the particular point on which observations are to be made, is sent to the observer at the secondary station. He assures himself that both observers are sighting on the same point of the assigned target, and then notifies them to be ready to observe. By means of the electric clock and bells, simultaneous observations at the two stations can be made. The battery commander sees that the replotted range and azimuth for the directing gun are sent to the guns; determines and applies the necessary corrections to this replotted range and azimuth and sees that the correct data, according to the "*Case*" employed, is sent to the guns. On receiving notification that the guns are aimed or laid, he sees that the observer at the secondary station is warned; gives the order for firing, or closes the firing circuit himself; observes fire, and notes errors in range and direction.

Range officer.—Assists the battery commander.

Observer.—Sights on target as ordered by battery commander, and is careful to be exactly on the target, when notified to observe either by word of command or by clock signal; calls to No. 1 the *azimuth* and, when so directed, the *range;* when the shot strikes the water, he sights on the splash and calls the azimuth to No. 1.

No. 1.—When the observer calls azimuth and range, No. 1 moves the replotter arm until its dials indicate this azimuth; moves the slider on the *principal arm* until the pencil point is opposite this range and presses the point down and makes a mark on the board; moves the *replotter arm* and the slider on the *secondary arm* until the pencil point of the latter is immediately over this mark; sends to the observer at the secondary station the azimuth indicated by the dials of the replotter arm in *this position* and the range indicated by the slider of the secondary arm, *these being the approximate azimuth and range of the target from the secondary station.*

When simultaneous observations are made on the target at the two base ends, No. 1 moves the replotter arm until its dials indicate the azimuth called by the observer at his station; moves the slider of the *principal arm* along that arm, pressing down the pencil point so as to make a line on the board which will contain the point of intersection; moves the replotter arm until its dials indicate the azimuth from the secondary station *appearing on the receiver of his dial-*

telegraph; moves the slider of the *secondary* arm so as to cross the line first made, pressing down the pencil point so as to make a short line on the board intersecting the first; the *point of intersection* will be the position of the target. He then moves the *replotter* arm and its range index until the pointer of the latter can be placed on the intersection determined as above, and calls the range indicated by the range index, and the azimuth indicated by the azimuth dials, *these being the replotted range and azimuth for the directing gun.* The operation for determining the replotted range and azimuth of the splash is performed in the same manner.

Nos. 2, 3, and 4.—Duties as described previously for the D. P. F.

Observer at secondary station.—Is provided with pencil, pad, and the necessary record blanks which he fills out in accordance with instructions; he receives by dial-telegraph, and notes the *approximate* range and azimuth of the target from his station, and such other information by dial-telegraph or telephone as will enable him to *identify* it and *the particular point* on which to observe; directs his telescope on the target, and when satisfied that he is on the selected point, signals to that effect to the principal station; stands ready for simultaneous observations at the bell signal; reads and immediately transmits the azimuth to the principal station and notes it on his record; when notified that the gun is to be fired, stands ready to observe the splash, and transmits the azimuth of the same as soon as read, making a record of it afterward; and so continues.

Telephone man.—Is provided with pencil and pad; operates telephone, and keeps a record of all important messages received or sent.

Moving Target.—Case I and Case II.

Battery commander.—It is important that the battery commander should get his observers on the target with the least possible delay, but he must also take pains to assure himself that no mistake has been made by the observer at the secondary station in getting on the proper target. It is an easy matter at practise, where but one towed target is used; but in action, where there may be several vessels of similar type maneuvering in close order, it will be much more difficult to identify the target assigned.

When assured that both observers are on the target, he directs the range officer to start the clock; sees that the replotted range and azimuth of the first position, and the direction of motion, of the target are sent to the guns; determines and applies the necessary corrections, and sees that the corrected data, according to the "*Case*" employed, is sent to the guns; gives the order to commence firing, and observes the fire.

Range officer.—Assists the battery commander; notes the *replotted range and azimuth* of the *first* and *second* positions of the target, and determines the *rate of change* in range and direction.

Observer at principal station.—Obtains *azimuth* and *approximate range* of target when directed by the battery commander, and calls them to No. 1; follows the target, stopping the telescope at each signal for observation, calling the azimuth to No. 1; and so continuing until directed to cease observing or to change target.

No. 1.—Notes range and azimuth of target as called by the observer, replots for secondary station, and immediately transmits results to that station by dial-telegraph. This may have to be repeated at intervals until the observer at the secondary station has *identified* the target. No. 1 determines the *replotted range* and *azimuth* for the *directing gun* after each signal for observation, and calls them out, until directed to stop.

Nos. 2 3, and 4.—Duties as previously described.

Observer at secondary station.—Identifies target and sends "*ready*" to principal station. He follows the target, stopping telescope at each signal for observation; reads and immediately sends azimuth to principal station, noting it on record blank; and so continues until he receives notification to cease observing or to change target.

Telephone man.—Duties as previously described.

Case III.—Predicted Firing.

The method described for the depression position-finder will be followed, with the modifications necessary to adapt it to a horizontal base, substituting the *replotting device* for the *replotter arm* of the type "A," D. P. F.

The range officer will determine the *rate of change in range* and *direction* for the use of the battery commander in predicting.

REPLOTTING CHART FOR HORIZONTAL BASE.

Instead of using the replotter board, it may be preferable to use a chart constructed in the following manner, on as large a scale as possible.

The base line is laid off so that the available field of fire will be included in the chart. From the point representing the *principal* station, *range circles* differing by 100 yards are described and numbered in black ink, and *azimuth lines* differing by 30 minutes for the shorter, and by 15 minutes for the longer ranges, are drawn and numbered in red ink. From the point representing the *secondary* station, similar azimuth lines are drawn and numbered in green ink.

If the chart is too large, it may be placed upon rollers attached to a table specially made for the purpose, and only that portion of the chart needed exposed to view.

Practise will enable the person who uses the chart to determine quickly the point of intersection of the lines whose azimuths are given from the base ends, and thus to determine the range and direction of any position of the target from the *principal* station. The battery commander applies the necessary corrections to these elements, and the corrected range and azimuth are sent to the guns, and converted there by means of a difference chart connecting each gun with the principal station.

FIRING FROM THE POSITION-FINDER STATION AT MOVING TARGET.

P is position-finder.
1, 2, 3, 4, 5—battery of five guns.
tt'—course of target.
Azimuth of *t'*—340° 31'.
Range—6750 yards.
Rate of change of azimuth—3° per minute.
Rate of change of range—180 yards per minute.

For illustration, take an interval sufficient to prepare the guns for firing, say three minutes.

This gives *T*, Az. 328° 31'; R. 6210 yards, which azimuth and range are sent to the guns and they are trained for direction on *T;* the range is only approximate, but is sent in order that the gun differences may be applied.

The battery commander sends the corrected range, about thirty seconds before firing, to the guns, which are elevated and made ready. He applies the deflection corrections to the position-finder azimuth of *T*, giving some position as *t''*, and when the target reaches this azimuth, fires.

It will be observed that the foregoing method is in reality direct firing, the aiming being done at the position-finder instead of at the guns.

Applying the deflection corrections at the position-finder is equivalent to applying them at the guns.

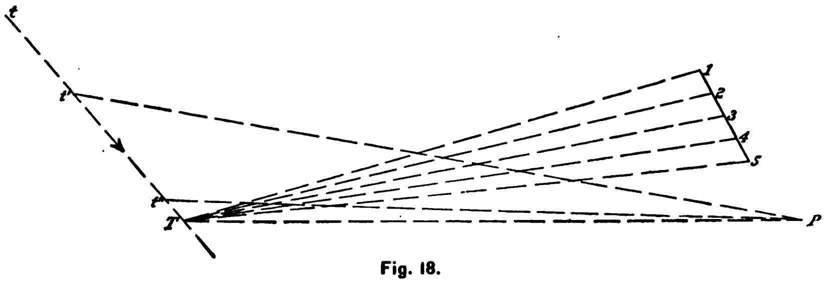

Fig. 18.

PART V.—COAST DEFENSE.

INTRODUCTORY.

Coast Defense comprises military and naval dispositions and operations to resist an attack from the sea. The line of defense is the coast line, the important points of which are the harbors and cities.

The means employed are naval forces for general defense; troops to resist landings; and fortifications, with an artillery armament, mines, and torpedoes, to avert or repulse a direct naval attack.

The Fixed Defenses of a harbor or contiguous portion of a coast line are distributed in groups covering the water and land approaches, and provided with lines of communication to each other and to observing stations for the transmission of intelligence and with facilities for the movement and concentration of troops.

The fixed defenses of a harbor constitute a Coast Fortress, which may be defined as an area of land and sea, provided at certain important points or along tactically selected lines, with works of defense, and with an artillery armament, partly fixed, partly movable.

This area is usually defined as the extent of land or water within range of its guns.

The *fixed armament* is mounted in forts or batteries.

Such defenses should provide cover for the stores and ammunition required for the service of the guns and accommodation for the garrison.

The guns forming the fixed armament are so disposed as to admit of concentration and distribution of fire upon the most important areas which they are assigned to defend.

In addition to the above, a Fortress is supplied with a *movable armament*, designed for use either within the forts or batteries themselves, to intensify the fire at any important point, to defend mine fields, and to attack lightly armored or unarmored vessels; or outside the forts, frequently in temporary works, for similar purposes, and also to resist boat attacks, to protect landing places, and to supplement from selected positions the artillery defense of the land fronts.

Wherever local conditions permit and require it, a system of *submarine mines* is maintained. These obstacles to the free passage of ships must be so placed that they are protected by artillery fire.

The service which Coast Artillery can render depends upon the character of the fortifications and armament, upon the organization and training of the personnel, and upon the proper employment of the arm.

It is not intended to enter into detailed descriptions of the material employed; this must be sought for in the various manuals. The main object is to secure the introduction of an organized system of training the personnel and employing the material to the best advantage.

Only general principles for fire control, fire direction, drill, and organization are laid down. It rests with local commanders to apply these principles.

GENERAL DEFINITIONS.

Fort.—Under Army regulations permanent posts are styled "Forts," the names being designated by the Secretary of War.

This term, in coast defense, has heretofore been applied to a permanent closed work.

Battery.—The term *battery* is used tactically to signify two or more guns (usually of the same caliber), their equipment and personnel, organized into a unity of command for service. The personnel constitutes an administrative unit called a battery. The term is also used to designate a number of guns in position for service, as well as the works in which the guns may be located. Wherever this term is used its meaning must be determined from the context.

Manning Detail.—This term, applied to any unit, means the personnel belonging to the same.

Manning Table.—A printed form on which to enter manning details. This form should *always* be kept filled up to date.

Fire Area.—The area of land or water, or both, which is effectively covered by the fire of the gun or other unit.

Electric Light Area.—The area of land or water effectively illuminated by an electric light.

Target.—The object at which to aim or fire a gun or guns, as a boat, a ship, or other object, whether stationary or moving.

Displacement.—The distance in yards from the vertical axis of the position finder working a battery to the pivot of the directing gun or some fixed point in the battery.

Gun Displacement.—The distance in yards from the pivot of any gun to the pivot of the directing gun or fixed point in the battery.

Gun Differences for any gun are the range and azimuth corrections to be applied at that gun because of its "gun displacement."

GENERAL PRINCIPALS.

The application of artillery fire to the best effect of which it is capable requires that the guns be combined into batteries for fire direction, and the batteries into commands for fire control.

It is important that a clear distinction should be drawn, and strictly maintained in practise, between "Fire Control" and "Fire Direction."

Wherever the words *control, direct,* and *direction* are used they will have technical signification as defined below.

FIRE CONTROL.

Fire Control is the conduct of any system of artillery defense for tactical objects.

The exercise of fire control consists in—

(*a*) The decision, *immediately on assuming command,* of the general lines on which action is to be taken under the different conditions of attack, and as far as possible of the details.

(*b*) Decision *beforehand* of the nature of projectiles to be used against different classes of ships at various ranges.

(*c*) Immediately before and during action, identification of class of enemy's vessels.

(*d*) Decision, as early as posible, as to the method by which the enemy proposes to attack the works, or to run past.

(e) Assigning to the different "battery commands" the vessels they are to *attack.*

(*f*) Unless previously decided, giving the signal for different units to open fire.

(*g*) Ordering the concentration or distribution of fire on enemy's ships as circumstances may require.

(*h*) During the whole period, a close and attentive observation of the various phases of the attack, and of the effect of his own fire.

(*i*) Decision as to the period at which fire is to cease.

(*k*) Insuring the proper record in the Fort Record Book of all permanent orders under the above heads.

FIRE DIRECTION.

Fire Direction consists in the technical administration of fire under the orders of the officer exercising *fire control.*

The duties of fire direction consist in—

(*a*) Making certain that the orders relative to projectiles and charges are thoroughly understood and complied with.

(*b*) Identifying particular targets assigned and transmitting this information to the guns.

(*c*) Communicating order and rate of fire.

(*d*) Observation and correction of fire.

(*e*) Change of target in compliance with superior order or on personal responsibility in the case of unforeseen emergency.

(*f*) Maintenance of fire, and cessation when ordered.

FIRE DISCIPLINE.

The ultimate condition of the various units, resulting from organization, drill, and combined practise, which enables the commander to direct fire of any desired nature and rate upon any objective, and to change the objective at will, constitutes *Fire Discipline.*

This condition can be established only by training the commissioned and enlisted personnel in the correct performance of their duties in all positions in which they are likely to be placed in active service. Constant drill and practise in preparation for service are essential in order that *fire control* and *fire direction* may be carried out.

DRILL.

The drills for the various guns of the armament will be based upon the following considerations:

Necessity for a simple and universal drill for guns of different types.

Separation of the different operations of serving the gun, and corresponding division of the detachment into details having, as far as possible, uniform duties, including ammunition supply.

Separation of the duties of giving elevation and giving training.

Permanent details for the position-finder and communications.

Necessity for reducing to a constant interval the time of accurately serving the gun.

ORGANIZATION.

Chain of Command: Fortress Commander—District Commander—Fire Commander—Battery Commander.

The Battery consists of two or more guns, their equipment, and personnel, organized into a unit of command for service.

The Battery Commander is in direct communication with his Fire Commander, from whom alone he receives orders, and to whom he is responsible for the *fire direction* and *fire discipline* of his command.

The battery should be composed of guns of the same nature and with fire over practically the same water area. Their height above the sea level should be approximately the same; their position should admit of salvo fire; the front of the battery should be limited to the extent which, under local conditions, admits of thorough fire direction, and the possibility of accurate ranging by salvos; the normal number of four guns should be adhered to as closely as possible.

The station of the battery commander will be the point from which he can best observe, correct, and direct the fire of his guns; it will generally be at or near the position-finder. He *should* have stations on the right and left of the guns; he will not, however, be restricted to the fixed stations, but is allowed the utmost freedom with regard to his position within his command. He must leave a responsible representative at his station when he finds it necessary to be away. This officer will at once take action on all orders received from the fire commander, and keep the battery commander informed of their purport.

The battery commander is responsible for the condition of his armament and equipment and the efficiency of his command.

The following are his duties in action:

He directs the fire of his guns on the target indicated to him by the fire commander; he prescribes the order and rate of fire; he is responsible that the prescribed projectile is used; for the accuracy of his fire, the supply of ammunition, the replacing of casualties, and the discipline of his command.

He will have two officers, at least, under him, one to be at the guns and one to be at the position-finder station.

The units of the battery are the Guns and the Position-finder.

A noncommissioned officer is in command of each gun; he is called a Gun Commander; his command consists of the gun, its mounting, implements, equipments, magazine, storerooms, and the personnel necessary for its efficient service. He is responsible to the battery commander for the condition of his material and the efficiency of the personnel.

In action, he will exercise supervision over his entire command; he is responsible that the orders of the battery commander are promptly and accurately executed; he will personally make the corrections that are ordered for the gun, and furnish the gunner with the elevation and deviation that is to be given; he will put in the fire plug and signal that he is ready, or repeat the command "fire," as the case may require.

There should be a *noncommissioned officer* in charge of the ammunition detail.

The *gunner* should be selected from those who have qualified in practise in gun laying.

The *privates* should be classified into first and second class in about equal proportions.

The Position-finder is provided with the necessary number of operators and assistants. The commissioned officer in charge will be held responsible for the condition of the material and the efficiency of the personnel.

Assignments at the *guns* and at the *position-finder* will be permanent, the object being to have each man thorough in a definite duty.

Batteries will be organized into *Fire Commands.* The grouping of batteries into fire commands will depend on local conditions, and upon the number that can be efficiently controlled by one officer.

Fire Commander.—The officer having command of, and fire control over, a fire command is termed a "Fire Commander." He exercises fire control through his battery commanders.

He will be responsible to his immediate superior for the efficiency of his command.

He must have a full knowledge of the nature and position of the mine fields and must also be aware generally of the disposition, etc., of the field forces protecting his flank or rear.

He exercises fire control from his station, which is a *position-finder station*, and from which the whole of the water area and the approaches thereto can be fully observed; it would be advantageous if this could be combined with a view over all the guns under his command.

He must have the necessary charts of the sea area and maps of the country surrounding, and all possible means of information which would enable him to judge of the character of the enemy directly he comes into view, and suitable means of transmitting information and indicating targets to his battery commanders.

Accommodation should be provided in the fire commander's station for his staff, consisting of an officer as assistant, the necessary observers, operators, and orderlies.

The *fire commander* will retain in his hands the control of fire as long as possible, but a time will come undoubtedly in every action when all or a portion of this control will have to pass into the hands of the battery commanders. The possibility of so holding this control will depend almost entirely on the training of the officers and men under conditions approximating as closely as possible to those of actual service.

A *fire command* is the lowest unit of executive fire control, and is a tactical unit only. The administrative unit—the "Fort"—will usually contain but one fire command, the fort commander being the fire commander. In case the fort should contain more than one fire command, the fort commander would be the senior fire commander.

Forts and their fire commands are organized into Districts.

A District will include one or more forts, with their fire commands, mine fields, and infantry positions. Their boundaries will be so traced as to include entire fire commands, all personnel and material following the guns.

Artillery being the main feature, the *command* should be vested in an artillery officer.

The District Commander may be the senior fort commander; in any case, he will have such staff as may be required.

He should have an intimate knowledge of the land and sea areas under his command, and of the surrounding country; he must have carefully considered, recorded, and practised the mode in which he would employ his units to meet the different possible forms of attack.

He is responsible that all his units are in a fit state for defense as regards their armament, ammunition, and personnel, and as to the means of supplying the latter with proper accommodations, water, and food. He must especially see that the communications throughout his entire command are in good working order.

Fortress Commander.—A Fortress may consist of one or more districts. It should be commanded by an officer of rank commensurate with the importance of the place. When not an artillery officer, he should have an artillery officer on his staff as adviser.

His permanent staff will include an armament officer, position-finding officer, and such other staff officers as may be necessary.

The precise duties will be laid down in orders for the different fortresses.

The permanent noncommissioned staff will consist of one or more armament sergeants, specialists, and artificers. The duties of these will be in connection with the armament, magazines, position-finders, communications, and general stores.

Communications.—These are necessary to join the several links in the chain of command.

Communication will be established: From fortress to district commander by telegraph or telephone; from district to fire commander by telegraph or telephone; from fire commander to his battery position-finders and to his batteries by telephone and telegraph or printing telegraph; from battery position-finder to guns by telephone or telegraph and by dial telegraph. (The battery commander is usually at or so near his position-finder as to be in direct speaking communication with it.)

In addition to such means of communication as have been mentioned, it is possible that local conditions may render others necessary or desirable, such as written orders, signals, etc.

Such an important part is played by *communications* that no pains should be spared in keeping them in perfect order; this can only be done by having them constantly cared for and operated. The lines should be so laid as to be secure from all interruption or interference. The terminals should be plainly lettered, and all information as to their use, and where the lines lead to, should be given. Speaking tubes or other means of oral communication should be established in the batteries as follows: between the observing stations and gun emplacements, between adjacent emplacements, and from each gun platform to the cartridge and shell room.

A code will be used, as far as practicable, to shorten messages. It will be adapted to local requirements, and must be thoroughly understood by all who are to use it.

STORAGE AND SUPPLY OF AMMUNITION.

There will, as a rule, be found at every fort, district, and fortress:

Main magazines for the storage of the general supply of ammunition.

Service magazines for each gun, comprising, in the new emplacements, cartridge, shell, shot, and store rooms, and capable of containing sufficient ammunition to last through a day's action.

The service magazines will be replenished from the main magazines at night, or when the command is out of action.

Cartridges for heavy guns are kept in wood or zinc cases and stored in the main and service magazines.

The system of marking by which powder is distinguished is as follows: First, the kind; second, the piece for which intended; third, the lot distinguished by the factory and year, a separate series of numbers for each kind of powder and piece or group of pieces using the same powder, and a new series beginning each calendar year, thus: Black sphero-hexagonal powder, for 12-inch mortars and siege cannon; California Powder Works, lot No. 2, 1897. To distinguish the lot it is sufficient to mention the kind, piece, factory, number, and year.

The cartridge bags and their storage cases are marked, showing the kind and weight of powder, the piece for which intended, the factory, the lot, and the year.

Ammunition will be stored by lots, and drawn upon by marks and dates, so as to insure, as far as possible, uniformity of fire.

Cartridge cases are placed on end, not more than three tiers high, with battens between.

Projectiles for the rifled guns in the United States service have practically the same form—a cylindrical body with a pointed head—the length varying from three to nearly four calibers.

For guns there are provided armor-piercing steel shot, cast-iron, solid, and *cored shot, cast-iron shell,* and an armor-piercing steel shell with high-explosive *bursting charge.*

For 12-inch mortars, steel (deck-piercing), torpedo, and cast-iron (common) shell, for both long and medium range, are provided; those for long range weigh 800 pounds; those for medium, 1,000 pounds.

In the main magazines projectiles are stored in their cases, marked with the kind, weight of projectile, and gun for which intended.

In the service magazines they are stored with cases removed.

They are marked with distinctive colors showing, at a glance, their nature, and, in case of shells, also the nature of the explosive charge with which they are filled.

They are piled in tiers with battens between tiers, shot with points to front or rear; shells with fuse hole toward the interior of the room, filled but usually without fuses.

Where no provision has been made in the service magazine for the storage of shot and shell, the shells are piled in a secure and convenient place near the gun; where necessarily exposed, they should be so placed that the explosion of one will not affect those adjacent to it. The shot will be piled at the most convenient part of the gun platform.

The arrangements for the supply and service of ammunition must be such that no check is likely to occur.

There are two methods of service:

Where the ammunition is on the level of the gun platform; where the ammunition is on a lower level.

In the first case, cartridges are carried by hand, by barrows, or by truck; projectiles, by barrows, by wheeled shell-tongs, or by truck.

In the second case, for guns of 8-inch caliber and upwards, where lifts are provided, cartridges and projectiles are sent up to the gun floor on lifts. Where platform cranes only are provided, the cartridges will be carried up by hand and the projectiles hoisted by the crane.

In the mortar batteries, the cartridges and projectiles are conveyed by overhead trolleys from the place of storage to points near the entrance to the gun pits, and from thence to the mortars, on trucks. In case provision has not been made for transporting the cartridges, they will be carried by hand.

For rapid-fire guns, the ammunition is carried by hand. The supply is placed in the ammunition storeroom in cases, a certain number of rounds being uncased for immediate service.

ELECTRIC LIGHTS.

Electric lights in coast defense will, as a rule, be used as fixed, divergent beams for the purpose of illuminating definite areas of water in connection with the defense of the mine fields and against raiding attacks of torpedo boats.

Electric lights, under favorable conditions of position and clear weather, will illuminate an object sufficiently to enable guns to be laid on it at ranges up to about 2,000 yards.

The attacking boat should be compelled to pass over an area which is within close range of the electric lights. The width of the channel will generally have to be reduced. This may be done by some form of obstruction, such as a breakwater, piles, or sunken vessels.

The lights should be so placed that, while they effectively illuminate the channel, the guns are left in the darkness.

They will be usually used in pairs, the distance apart depending on local conditions.

Dispersing lenses should be provided to throw out a beam of great breadth *and little height,* and concentrating lenses, for long range.

MANNING A FIRE COMMAND.

Organizations will, as a rule, be permanently assigned to the various units of the command.

A *form* will be provided, filled up, and kept posted, giving the officers, noncommissioned officers, and men required to man the various units.

This form will show the fire commander, battery commanders, assistants, observers, telegraph, telephone, and dial men, by name, the strength of the batteries, gun detachments, and the other details.

A copy of this will be furnished the fire commander and extracts to the battery commanders.

At the signal to man the works, the fire commander and his details will proceed to the fire commander's station, which is an equipped position-finding station; each battery command will be formed in accordance with the manning table, the detachments and details verified and reported by their commanders; the battery commander will then proceed to his post, test his communications, and prepare his maps and charts; one subaltern, the *range officer*, with the position-finding detail, proceeds to the position-finding station, examines and puts everything in order, and reports to the battery commander.

The other subaltern, the battery officer, proceeds to the guns. Each gun commander marches his detachment to the rear of the gun emplacement, halts it, and gives the command—*Prepare for action* [*or drill*]—and afterwards—*Examine gun.*

The implements, equipments, and other stores are then brought up from the emplacement store rooms and placed in position about the gun, and a careful inspection of the gun, carriage, buffers, gears, etc., and of all the other appliances connected with the service of the piece, is made. The gun commander, having received the report of the ammunition gunner that everything connected with the service of ammunition is in working order, and after seeing that all the details are at their proper stations and understand their duties, makes his report to the battery officer, who then inspects the guns, and, when satisfied that the guns *are* in all respects ready, makes the report to the battery commander. If anything is out of order, so that he can not immediately rectify it, he will report the fact at once.

The battery commander then reports to his fire commander.

Where a command is to man a work for the *first time*, it will be met by an officer or noncommissioned officer of the local staff, who will furnish all necessary information and assistance.

In case of *imminent danger*, battery commands will be kept in a state of preparedness, but this should be carried on in such a way as to entail as little hardship on the men as the case will admit of. It is important that instruments should be set up ready for use, that all stores should be at the guns, that the telephones should be manned; and at night, guns loaded and trained and lights in place.

In case of *sudden alarm*, battery commanders will act without waiting for orders, in accordance with previous arrangements to meet the contingency.

FIGHTING A FIRE COMMAND.

The post of the *fire commander* is usually a position-finding station; he is in communication with his district or fortress commander, with his battery position-finder stations, and with his batteries.

His command being manned, is reported ready, and he receives such general instructions as are to govern him.

He assigns the targets to his batteries, gives the command to commence firing, *observes the course of the* engagement, changes the target when necessary, changes the projectile, concentrates or distributes the fire, but should, as a rule, leave *fire direction* to the battery commanders, *interfering only when necessary.*

Should a battery position-finder be put out of action, he may assign the battery to another position-finder for target and range.

The *battery commander* is provided with an instrument for *observation of fire,* and will take *the station* from which he can best observe the results; his *battery* is provided with a *position-finder* (depression or horizontal base), and with communications from the *position-finder* to the *battery,* and from the battery commander's *stations* to the *guns* and to the *position-finder,* and with interior communications, telegraph, telephone, dial, visual, speaking tubes, etc., as may be best adapted to each case.

The target having been indicated by the *fire commander,* the battery commanders will cause it to be at once taken up by their observers and gun commanders; the latter will have their guns loaded and trained ahead of the target.

The observed range and azimuth for the central, or *directing gun,* is furnished by the position-finder. To these the *battery commander* will apply the corrections for powder, tide, wind, atmosphere, speed, and direction of target, and observed fall of projectile, and communicate the corrected range and azimuth to the guns. The *gun commanders* will apply the necessary corrections for the gun displacement. In case of indirect laying, predictions for a constant interval —say one minute—in advance will be made, corrected, communicated, and applied as above.

The battery commander will direct the kind, rate, and order of fire. Salvo fire is in general the most effective. In this case, the battery will be fired on signal from, or electrically by, the battery commander. The efficiency of the gun will be greatly increased if it be provided with power, so that the gunner, by a wheel or lever, can elevate and train it.

There may be differences in the installations of position-finders and communications for different batteries, but the object in all is to facilitate fire control and fire direction, and to increase the number of well-aimed shots in a given time.

Constant practise is necessary to make the system effective and to further develop and perfect it.

GENERAL PRINCIPLES OF DEFENSE.

A fleet will attack land defenses—

(*a*) By bombardment at long, medium, or close ranges;

(*b*) By attacks on the mine fields and attempts to run by the batteries.

The best method of meeting these forms of attack will depend—

(*a*) Upon the strength of the ships, the power of their armament, and the speed;

(*b*) The position of the batteries and the power of their armament;

(*c*) The area and depth of water the fleet can make use of;

(*d*) And upon the form and depth of the channel.

The batteries can attack the decks by high-angle fire; the upper structure, unarmored, and lightly armored parts, and the belt and heavily armored parts, by direct fire.

In any case, the target must be identified and the form of attack decided upon.

Identification of ships.—To decide the best method of attack, the character and resisting power of the vessels to be engaged must be known. Identification and attack sheets are furnished; the former consist of drawings of the different types of ships, with all the information that may be of use for identification and fire control; the latter consist of diagrams for the use of the battery commander.

Fire tactics.—Fire should be opened at long range with common percussion shell, and continued until the decrease in the range brings the armored deck within the power of the gun, when armor-piercing projectiles will be used, and their use continued until the angle of descent falls below ten degrees, when the use of common percussion will be resumed and continued until the range has decreased to the point where the *vertical armor* can be penetrated, when the use of armor-piercing projectiles will be resumed.

In determining the points at which to use armor-piercing projectiles, the size of the target, the power and accuracy of the gun, the limits within which the range is known, and the inclination of the course of the target to the line of fire must all be considered. The target should preferably be the belt, aiming at the water line.

The attack of the unarmored parts should be continued simultaneously with the attack of the armor, the latter task being assigned to a portion only of the heavy armament.

Rapid-fire and machine guns should be employed to keep down the fire of the secondary armament and to fire at the ports and barbettes.

Mortar fire will be used at long and medium ranges; at the long ranges, use the lighter shell (common or deck-piercing, as the target may require); at the medium ranges, use the heavier projectile (common or deck-piercing, as the target may require).

Battery commanders will be provided with tables from which, being given the target and the approximate range, the proper projectile is at once determined. These tables are constructed in conformity with the above principles.

For ships at rest, or in motion at long ranges, the principles already laid down need no further amplification for their correct local application.

Ships are, however, not constructed to fight forts or land batteries. They are not a match at long ranges, because of the limited elevation that can be given their guns, the impracticability of their carrying mortars, and their unsteady platforms. They are not a match at close ranges, because modern high-power guns are more effective against armor than against earth or masonry, and because of the low platform and small target. Ships will therefore attempt to run past, aiming to take the forts unawares or with as little notice as possible, and to pass at the best speed consistent with safety.

They may make the attempt at night, or, closing in under cover of darkness, steam by at break of day.

The time that they will be exposed to fire will be short. There will be no time for use of position-finders. The *target* and its *speed* will be about all the information that can be furnished the guns. The ship in advance should be selected by preference. The heaviest fire should be brought to bear when the target is at shortest range and moving at right angles to the line of fire. The number of shots that any gun can deliver will depend upon the speed of the target and upon the time consumed in serving and aiming the gun.

In conformity with the above principles, fixed trainings should be marked on the traverse circles of the guns and the corresponding ranges recorded in a convenient place. These will be entered in the Fort Record Book and in the battery commander's tables.

Defense of the mine fields.—So long as a properly planted and operated mine field is intact, ships can not pass over it.

Mines can be removed or exploded by dragging, grappling with ordinary or explosive grapple, and by countermining.

Dragging and grappling are conducted from small boats specially fitted up for the purpose. Countermining is done by small vessels dropping charges of high explosives near the mines and then moving to a safe distance and firing the charges, or by throwing large charges of high explosives from pneumatic guns, the shots being placed successively so as to clear a channel through the mine field.

These operations would be undertaken under cover of darkness or fog by small unarmored boats.

Defense.—The mine fields should be covered by the fire of a portion of the most powerful armament.

The area in front of the field should be illuminated by fixed electric beams of sufficient power to expose any boat passing through. There should be movable beams to pick up the boat so discovered and to follow it up.

Rapid-fire and machine guns should be so grouped as to effectively cover the area. Each group of guns should be a separate command. There will be neither time nor necessity for superior command, nor for the use of range-finding instruments. Ranging will be done with the guns or other means of rapid estimation.

The old smooth-bore guns may be utilized in the defense of the mine fields, but their use must not be allowed to interfere with that of the rapid-fire and machine guns. The importance of rapid-fire and machine guns can not be overestimated. A large number of them is absolutely necessary.

Floating defenses should also be provided, for on foggy nights the electric lights have little penetrative power, and small boats can evade the guns on the shore.

ATTACK OF TORPEDO BOATS.

The water area over which these boats can pass is usually very wide on account of their light draft. They have great speed, and are so colored as to be very inconspicuous. Their aim will be to pass the forts and destroy the shipping in the harbor.

The same remarks as made on the defense of the mine fields are applicable, only the necessity for large numbers of rapid-fire guns, for obstructions, and for floating defenses is emphasized.

FORT RECORD BOOK.

At every artillery post a permanent record will be kept of all the details of the works, their general object, history, and armament, as well as details connected with their organization both in peace and war, which will be in accordance with the *defense scheme.*

It is the duty of the *commanding officer* to keep up the record of details of the above nature so complete that an officer taking charge will find all the information that he can require, ready at hand, and in the fullest detail.

It will contain details of all the information referred to in this manual, so far as they apply, so that if tables are lost, or figures in the gun emplacements or stations are erased, they can be immediately restored.

It will be clearly indexed, and kept as confidential.

It will be arranged under the following heads:

1. General Description.

Of the works and their surroundings (land and water), history, objects, the fire commands to which they belong, the depth, width, and direction of the channels, the height and set of the tide, the strength of the current, the position of the mine fields and other obstructions, the barrack, camp, and hospital accommodations, the water supply, the landings, the labor and transportation available, etc.

2. Fortifications.

All details of construction, nature, and thickness of parapets, traverses, magazine cover, etc., dimensions and capacity of magazine, storerooms, etc., with plans and sections.

3. *Armament.*

Fixed armament.—The guns constituting each battery, their emplacement, caliber, number, mounting, height above mean low water, the capacity of their recoil cylinders, sectors of fire, actual contents and capacity of the service magazines, means of serving ammunition, the position-finding station and its equipment, the communications, important azimuths for each gun and position-finder for orientation, etc.

Movable armament.—The same as above, and in addition the place of storage of the guns when not in position.

Mines.—Their supplies and storerooms, maps of the mine fields, and instructions for planting and operating them, etc.

4. *Auxiliaries.*

Communications.—Lines, conduits, purpose, terminals, markings, references to the map, etc.

Position-finders.—Stations, equipment, important azimuths, and distances, etc.

Electric lights.—Kinds, numbers, power, arcs of illumination, emplacement, etc.

Maps, charts, and tables.—Maps of the post, surrounding country, harbor, communications, etc.; fire and battery commanders' charts, etc.; tide, range, and other tables.

5. *Plans of Defense.*

Preparations when war is imminent.—Details of mobilization, additional constructions, such as traverses, shelters, intrenchments, ground mines, entanglements, etc.

Defense scheme.—Complete, detailed schemes for meeting the different possible forms and phases of attack.

6. *Journal.*

In which will be recorded as they occur all transactions permanently affecting the works or likely to be historically or technically of use or interest to future commanding officers.

NOTE.

Commanding officers will make themselves masters of this book; they will test its provisions, and point out any that can not be carried out or that are capable of improvement.

EMPLOYMENT OF MILITIA.

Where the militia are authorized to receive instruction in the service of coast artillery, the *district commander* will, in his plan of defense for mobilization, provide for the distribution of the several organizations to the works and quarters to be allotted to their use while training.

These organizations will be trained with special reference to the works they may be called upon to man, and individual officers, noncommissioned officers, and men should be allotted to certain specific duties, and be rigidly kept to these duties while training.

All officers for commands superior to the battery, staff officers, and all specialists, etc., will be detailed by the *district* or *fortress commander.*

The distribution of these organizations for the various "forts" will be recorded in the Fort Record Book, and on their arrival steps should be at once taken to perfect their training.

PART VI.—PRACTISE.

INTRODUCTORY.

The rules and instructions contained in this chapter are intended as a general guide; specific instructions will be given in orders.

The object of all practise being preparation for service, fire commanders, battery commanders, gun commanders, gunners, gun, ammunition, and position-finder details, telephone and dial operators, etc., should constantly rehearse their respective parts, the command working together as a unit.

Commanders of units will be allowed the greatest freedom in conducting firing in their respective commands. *Tactical superiors* will closely observe the practise, exercising a general command, and, at its conclusion, giving such instructions as may seem to them necessary to correct any errors committed.

Reports will be submitted to the immediate superior, who will note thereon his criticisms of the practise, and his remarks with respect to the drill and fire discipline of the command.

Before conducting battery or service practise with the guns of any particular battery of the new armament, the commanding officer of the post will cause each gun as mounted for service to be tested as to its performance and precision of fire. The guns composing each battery will be adjusted and ranged with respect to each other for uniformity of fire, and the mean error of the battery at different ranges determined. In firing for the above purposes, steps will be taken to obtain the most accurate and complete data; initial velocity and pressures will be measured when practicable; the atmospheric conditions and variations of density of loading will be noted; the targets and points of impact will be carefully observed and platted. Precision is of prime, time of secondary, importance in this firing.

The results will be formulated and carefully recorded in the Fort Record Book for future guidance of the garrison.

CLASSIFICATION OF PRACTISE

(I) Battery practise:
  (*a*) Elementary;
  (*b*) Ranging (at fixed and moving targets).
(II) Service practise:
  (*a*) Fire command;
  (*b*) District or Fortress.

These classes must be kept entirely distinct, and the particular objects of each kept constantly in view in arranging the details. The resources of each kind of practise should be exhausted before proceeding to the next higher class.

BATTERY PRACTISE.

(*a*) *Elementary.*—This practise can be carried out with the lightest caliber of guns, provided they are mounted on traversing carriages and conform, in the essential operations, to the larger guns. The supply of ammunition should be liberal.

The object is to teach practically the recruits and young soldiers the details of correct service of the guns and the principles of fire discipline.

Instruction should cover the following points: Aiming (elevation and direction); the effect of deviating forces; the necessity for rapid and correct service, and the results of errors committed; cutting fuses; ranging; observation and correction of fire; the effects of fire with different classes of projectiles.

(*b*) *Ranging practise.*—This practise should be conducted with the guns permanently assigned to the battery, or with guns of the same caliber and mounting, if possible.

The object is to train the battery officers in the *observation of fire;* to test the powder and to determine the mean error of the fuses; to verify the range tables, sights, and the level and graduation of the traverse circles, and to test the qualified gunners.

The firing will be conducted at fixed and, where practicable, at moving targets.

At fixed targets, more than one range should be used.

At moving targets, the range should not be over 3,000 yards, and the target's course should not make a less angle than 45 degrees with the line of fire.

In the preparation of the reports, the very greatest care should be taken that the fullest and most accurate information is recorded, and too much attention to accuracy can not be paid by the range party. For it is by the careful study of the range reports that we get the vast amount of information regarding the laying, and the setting of fuses of the battery, and are able to deduce the average variation in the ranging of projectiles and the burning of fuses.

SERVICE PRACTISE.

The object is to train the officers in the correct *administration of fire,* to test the *fire discipline* of the command, and to ascertain its fitness for service.

(*a*) *Fire command.*—The personnel will take positions for action. The practise will be carried out under a general idea framed to illustrate some phase of an action.

Several targets should be placed so that the fire commander may have a choice in assignment, and may shift from one target to another. It will not, as a rule, be practicable for more than one battery to fire at the same time on account of the difficulty of observation, and danger. Where a moving target is used, but one should be employed at a time.

The *record* should be made independently of, and, as far as practicable, without interfering with, the work of the fire command.

Where service ammunition can not be used, blank may be employed, and attacking vessels represented by small boats or launches. The courses of the boats will be platted, the elevation and training of the guns for each shot and the time of firing recorded. From this data, a relative value can be given to the practise.

(*b*) *District or Fortress.*—It would be desirable to obtain the cooperation of the Navy for carrying out periodically a comprehensive scheme of attack and defense of a fortified harbor, by which all the means of defense could be tested.

NIGHT PRACTISE.

While no firing of service ammunition will be practicable, nevertheless the following can be advantageously practised:

Manning the works;
Serving the guns, instruments, etc.;
Operating the search lights;
Testing the lighting generally;
Taking and communicating ranges.

OBSERVATION OF FIRE.

This duty and that of position-finding can not, as a rule, be performed at the same instrument.

The observation upon which it is necessary to rely in action is made from the battery commander's station, and it can not be sufficiently exact to satisfy the requirements of ranging practise. To aid in service observation, a supplemental position-finder or a good telescope will be provided. The telescope of the observing instruments should have large enough field of view to include, when its axis is directed on the target, all the probable points of fall. Vertical and horizontal hair lines placed in the focus at definite intervals, will aid in accurate estimation, especially at moving targets.

In ranging practise, while the officer directing the fire should *practise observation* under the usual conditions of service, *observers* are stationed in a favorable position with respect to the target and guns, from which the fall of the projectiles can be *accurately* determined for platting. This data will, by comparison, check the errors of service observation and furnish the means of preparing or correcting range tables, etc.

Observation for this practise may be made—

(*a*) From the ends of base lines suitably selected. Three stations are desirable; all should be occupied whenever practicable.

The azimuths of the points of fall, the angles made with the base line, or the angles (minutes) right or left of the target, are measured and transmitted to the platting station.

(*b*) By depression position-finder, the deviation being measured on the azimuth circle and the distance "short" or "beyond" on the range scale.

(*c*) By range party near the target. Where the target is fixed, the range party will take station on a line approximately at right angles to the line joining the gun and targets (preferably on the left) and at a distance from the target of at least one-tenth the range; in case of a moving target, the station of the range party is on the towing boat. The towline should be at least 300 yards long. This method gives the most reliable information.

A "T" with the head subdivided to hundredths of the length of the arm is a simple appliance which may be used in measuring, by observation, the distance of impact or burst short of or beyond the target.

PLATTING.

Where methods *b* or *c* are used, no platting is necessary, as the desired information is furnished directly; but it is necessary in case *a* to plat the angles to obtain the errors in range and direction. This may be done in two ways:

(1) Where azimuths or angles made with the base are sent in, the ordinary platting board is used.

(2) Where deviations from the target, as observed from the base ends, are sent in, the following method will give rapid and accurate results. Through the center of a sheet of paper representing the area around the target, on a scale of, say, 1 inch to 10 yards, a line is drawn to represent the line joining the gun and target, and minute lines right and left, corresponding to each base end; these minute lines are numbered to indicate the number of minutes deviation right or left.

The deviations having been received from the base ends, the point of impact is determined by the intersection of the two corresponding lines. The scale is so large that there is no difficulty in reading at once the short or beyond and the right or left. The chart being constructed at leisure, there is no occasion for any error in platting.

RANGING.

The principles applicable to service must be observed.

The object is to adjust and regulate the fire by placing the mean point of impact on the target and keeping it there.

The means are a position-finder, an auxiliary rapid-fire gun, when the latter is accurately sighted for the ammunition used, or the *gun* itself.

The method consists in the establishment of a bracket by throwing a projectile short of and one beyond the target, or the reverse. An intermediate elevation is then given, reducing the limits within which the range is unknown, and this process is continued until the center of impact is placed on the desired part of the vessel. In regulating the fire on the target, the character of the latter, with respect to height or depth, should be considered. In case of a vessel, not more than one-fourth of the projectiles should strike short of the water line.

In *coast artillery*, a battery of heavy guns without a range-finding instrument is not contemplated.

The details of the methods of ranging will depend upon the nature, speed, and direction of the target, the nature of the guns, and the instruments available.

The elevation and deflection of the first shot will be that for the measured or estimated range, corrected for powder, wind, atmospheric conditions, tide, speed and direction of the target.

The fall of the shot is observed by the best available means, and, except in the case of a hit, a change of elevation is given to the next shot, which will insure its bracketing the target. This is continued until the target is inclosed within a zone the depth of which is *twice* the mean error of the gun.

In the case of a hit, no change in elevation would be made.

In ranging at moving targets, it must be remembered that as a rule it will be very difficult to estimate the amount beyond or short that a shot falls, also that, to save time and ammunition, alterations in elevation must be sufficiently bold.

In practising or firing by prediction, the range and azimuth of the predicted position are furnished by the position-finder. The interval between predictions should be sufficient to allow the correction to be applied, the range and azimuth communicated, the guns laid, and the projectile to arrive at the predicted point at the same instant as the vessel.

Practise will determine what this interval should be. It should be made as constant as possible by careful drill.

When the guns are of small caliber and the objective, torpedo boats, or boats carrying landing parties or attacking mine fields, and the position-finder not practicable, the following methods would be observed:

One or two of the leeward guns should be told off as *ranging* guns, and, when the range is found, all the guns, with an elevation corresponding to this range, will open a *rapid fire* on the target.

When the target is moving *toward* the guns, the ranging guns are fired deliberately with an elevation short of the estimated range of the target, continuing with the same elevation, until a shot is observed to fall beyond, when all the guns open a rapid fire, at a slightly decreased elevation.

Every effort will be made to keep on the target as long as possible. If, however, the fire is observed to be ineffective, the ranging guns will establish a second point, and the battery proceed as before.

The same method will be pursued when the target is moving ***straight from*** the guns, except that the ranging guns establish a point beyond the target, and the fire is opened with a slightly increased elevation as soon as a shot is observed to fall short of the target.

When the target is moving directly across the line of fire, the ranging will be *the same as for a stationary* target, when moving obliquely across the line of fire, ranging must be left to discretion to adopt any of the foregoing methods or a combination of them, according to the obliquity of the movement of the target with respect to the line of fire.

In connection with ranging at moving targets, it must be remembered that it is not the actual rate or speed of the target that it is necessary to know, but in what time or how quickly the ranges change. By the use of a watch, in connection with a position-finder, this alteration can easily be ascertained for any number of seconds by observing the ranges recorded on the dials.

The following rules may be found useful:

The speed of target in yards per second is equal to one-half the speed in miles per hour.

Deflection correction in minutes of arc is equal to the number of degrees in the angle passed over per minute × time of flight (time for the gunner to step clear must be included).

In case of M. L. R., the deflection correction is approximately equal to range in yards × degrees of angular change per minute divided by 400; in case of B. L. R., for service charges, the divisor is 600, and for practise charges, 500; both rules being based on the fact that the range in yards divided by a constant quantity gives approximately the time of flight in seconds.

TARGETS.

Targets are either moored or moving. Moored targets are laid down by the range party, under the supervision of the range officer, and according to the directions given by the officer commanding the practice.

They are so moored as to be practically fixed in position. A mooring rope, buoy and buoy line, and anchor are required for each target. In very deep water two anchors may be necessary.

The mooring rope is attached to the target by a fisherman's bend and the end seized. The other end of the rope is similarly secured to the anchor ring and seized. The buoy line is secured to the buoy in the same manner, and the other end of the line is secured to the anchor by one half hitch around each arm and two half-hitches around the shank and the end seized to the shank. The buoy line should be no heavier than is necessary for hauling out the anchor.

When moored targets are used, not less than two, and, if possible, more, should be placed in position not less than 3° apart and at various ranges, differing as widely as the locality will allow.

Moving targets constructed so as to offer the least resistance should be towed with a length of tow rope not less than 300 yards long, and with a speed of between 7 and 15 miles per hour.

The course over which the target is to be towed should be accurately determined by the aid of charts before the practise commences, and, if possible, buoyed.

A diagram of the course will be attached to the report.

RULES FOR PRACTISE AT MOVING TARGETS.

1. The only projectiles allowed, when practising at a towed target, are shot or plugged shell.

2. Fire should be opened on the target under the following conditions:

   (i) When the target is moving on a line roughly parallel to the front of the battery, or an arc of which the battery is the center.

   (ii) When the target is approaching the battery at an angle of not less than 45° to the line of fire.

3. Under no circumstances whatever shall fire be opened on a towed target when—

   (i) It is being towed from the battery;
   (ii) It is outside the buoyed or prearranged course;
   (iii) It is at a greater range than 3,000 yards.
   This limit may be increased to 4,000 yards with a tow rope of 400 yards, provided the guns are mounted at a height of 400 feet or over above mean tide level.

4. *The range officer will be posted* on the tug. He will *hoist* a red flag when the target enters the course, and will *keep it flying* so long as under the above rules practise may continue at the target. Should the tow rope become so slack as to materially diminish the distance between the target and tug, he will *lower* his flag.

5. The officer commanding the practise is responsible that the range is clear, and will *hoist* a red flag as soon as he is ready to commence practise, provided that the flag on the tug is up, and will keep it hoisted until the practise is completed, with the following exceptions:

   (i) If the flag be hauled down *on board the tug*, the flag *in the battery* will be hauled down, to be rehoisted simultaneously with the other.
   (ii) If the range be in any manner interrupted, the flags will be hauled down. When local conditions render it difficult for him to see that the range is clear, he may appoint "danger officers" to assist him in his duties. These officers are responsible that the range is clear from their point of view, and are empowered to order "cease firing" at their discretion.

6. No gun is on any account to be fired unless both flags (on tug and in battery) are *hoisted*. On the termination of the practise, a white flag will be hoisted at the battery.

7. The commanding officer in the battery and the range officer will each be provided with a diagram of the proposed course. On the diagram the extreme lateral limits of the course will be clearly marked.

8. The annexed diagram illustrates the meaning of the rules in paragraphs 2 and 3.

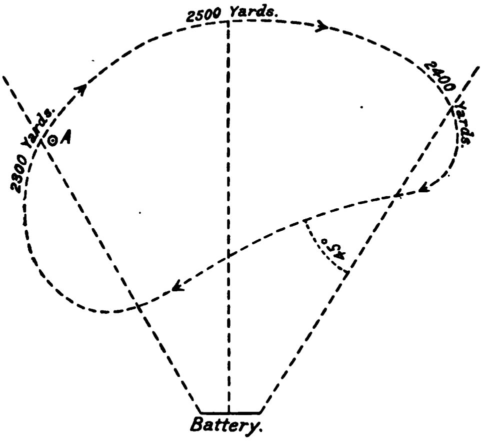

Fig. 19.—Proposed course for a moving target.

Steamer enters the course at *A*, passing close to buoy there. The target may *be fired at over any part* of the space included between the dotted chain lines.

PRECAUTIONS FOR SAFETY.

The officer commanding the practise is responsible for the safety and clearness of the range from the battery to the target, and as far beyond as he can see.

He is responsible that the range beyond the target is in distinct view either of himself or of the range party.

No practise is to be carried on unless the area covered by the last ricochet is well within the observation of some responsible person.

It is also his duty to see that all reasonable precautions are taken to avoid injury to public or private property.

Although the gunner is responsible for the adjustment of the sights and laying the gun under the gun commander, the officer *in immediate charge* of the guns must take every precaution to satisfy himself that the true object is aimed at, and that no error is made that may endanger the range party or others.

In practise at moving targets, it is well for him to ascertain that the tug has passed before the gun is fired.

The *range party near the target* is always provided with a red flag or other distinctive signal, which is not to be hoisted, lowered, or used for signaling except by the direct order of the responsible officer. When it is *displayed* it is an indication that all is *safe* and that firing may proceed.

The red flag or other distinctive signal at the battery is not to be *hoisted, lowered,* or *used for signaling* except by the order of the officer commanding on the spot. It will be hoisted before firing, even when using blank cartridges.

When the fire commander, or other officer commanding the practise, deems it necessary or receives a caution to cease firing, either by the lowering of the range flag or other indication, he will command *cease firing.* This order must be instantly repeated by the officers responsible for the service of the guns. At this command, the lanyard is detached, or in case of electric firing, one wire from the firing battery is disconnected at the gun or the mechanism put to "safety." If a gun is being loaded, the operation will be completed.

If there are any signals agreed upon locally between the battery and the range party, they should be formally issued, and a copy of them in the possession of both parties during the practise.

No projectile will be fired over a vessel.

For any range of rifle projectiles less than the range of no ricochet, the total distance of travel of the projectile does not greatly exceed the range of no ricochet. The range must be clear for a distance equal to the range for which there is no ricochet. Seven degrees to the right and to the left of the line joining the guns and target is a sufficient allowance for safety short of the target; and 10° to the left and 15° to the right, for the area beyond the target.

TABLES OF FIRE.

The following tables are specimens of tables of fire:

No. 1 is a general table which furnishes the data for constructing the service tables.

No. 2 is for the fire commander.

No. 3 is for the battery commander.

Nos. 4 and 5 are for the gun commander.

Certain variations may be necessary in the service tables, the object being to have in ready form the necessary information for immediate use with the sights and mechanical contrivances used for conversion and correction.

TABLE NO. 1.—GENERAL RANGE TABLE.

8-inch B. L. R.

I. V., 1 950 foot-seconds. Charge, 125 pounds Br. Pris. powder. Weight of projectile, 300 pounds.

Range X.	Angle of departure ϕ		$\Delta C = \pm$ to $\frac{1}{10}$ C.	$\Delta V = \pm 50$ F.S.	ΔX for 10-mile wind.	Time of flight.	Drift.	Dev. for 10-mile wind.	Max. ord.	Angle of fall ω		Striking velocity.	Penetration in steel.	Slope of fall.
Yards.	°	′	$\Delta\phi_1 = \pm$	$\Delta\phi_1 =$	*Yards.*	*Sec.*	*Yards.*	*Yards.*	*Feet.*	°	′	*F. S.*	*In.*	*1 on*
1,000	0	46.3	.2	2	1	1.6	.3	.05	12	0	48	1,797	14.2	75
2,000	1	37.7	1.2	4.5	2	3.34	1.2	.9	45	1	49	1,656	12.6	33
3,000	2	35.4	2.8	7.2	5	5.23	2.9	2.13	112	3	3	1,526	11.2	20
4,000	3	40	5.4	10.9	9	7.29	5.6	3.88	216	4	33	1,410	10	13
5,000	4	52.8	9.1	15.6	12	9.52	9.7	6.25	366	6	23	1,303	9	9
6,000	6	14.4	14.3	19	18	11.94	15.4	9	576	8	33	1,212	8.1	7
7,000	7	45.5	21.2	23.2	24	14.56	23.2	13.25	861	11	7	1,137	7.4	5
8,000	9	27.4	29.5	28.8	30	17.37	33.5	17.64	1,249	14	2	1,081	6.9	4
9,000	11	19.6	39.3	35.1	39	20.34	46.7	23.42	1,875	17	13	1,043	6.5	3

NOTE.—General table calculated for every thousand yards. By plotting the results (changing minutes to yards and the reverse, when necessary) on cross-section paper, the intermediate points may conveniently be taken off for filling out the service tables (Nos. 2, 3, and 4).

TABLE NO. 2.—FIRE COMMANDER'S TABLE.

10-inch B. L. R.

Range.	Angle of fall.		Striking velocity.	Penetration steel.
Yards.	°	′	*Ft. sec.*	*Inches.*
5,000	7	21.6	1,251.3	10.6
6,000	9	38.6	1,176.1	9.7
7,000	12	14.3	1,121.6	9.1
8,000	15	2.1	1,081.0	8.6
9,000	18	12.8	1,052.8	8.3

8-inch B. L. R.

3,000	3	3	1,526	11.2
4,000	4	33	1,410	10.0
5,000	6	23	1,303	9.0
6,000	8	33	1,212	8.1
7,000	11	7	1,137	7.4
8,000	14	2	1,081	6.9
9,000	17	13	1,043	6.5

TABLE NO. 3.—BATTERY COMMANDER'S TABLE.

8-inch B. L. R.

I. V., 1,950 foot-seconds. Charge, 125 pounds. Weight of projectile, 300 pounds.

Range corrections.						Deviation corrections.					50 per cent zone.		
$.01\frac{\delta_1}{\delta}$.	10 foot-seconds I. V.	Tide 1 foot dif. level.	10-mile wind.	Travel [during time of flight] 10 miles per hour.	Range.	Drift.	10-mile wind.	Travel [during time of flight] 10 miles per hour.	1 yard, right or left.	Penetration in steel.	Length.	Breadth.	Height.
Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Min.*	*Min.*	*Min.*	*Min.*	*In.*	*Yds.*	*Yds.*	*Ft.*
1	8	24	1	8	1,000	1	1	29	3.6	14	------	------	------
1	10	21	1	10	1,200	1	1	29	3.0	14	------	------	------
1	11	18	1	12	1,400	1	1	29	2.6	14	------	------	------
1	13	15	1	13	1,600	1	2	29	2.2	13	------	------	------
2	14	13	2	15	1,800	1	2	30	2.0	13	------	------	------
2	17	11	2	17	2,000	2	3	30	1.8	13	------	------	------
3	18	10	3	19	2,200	2	3	30	1.6	12	------	------	------
3	19	9	3	21	2,400	2	3	30	1.5	12	------	------	------
4	20	8	4	22	2,600	2	3	31	1.4	12	------	------	------
4	22	7	4	24	2,800	2	4	31	1.3	12	------	------	------
5	23	6	5	26	3,000	3	4	31	1.2	11	------	------	------
5	25	6	6	28	3,200	3	4	32	1.1	11	------	------	------
6	26	5	7	30	3,400	3	4	32	1.0	11	------	------	------
6	27	5	8	32	3,600	4	4	32	1.0	11	------	------	------
7	29	5	8	34	3,800	4	5	32	.9	11	------	------	------
8	30	4	9	36	4,000	5	5	33	.9	10	------	------	------
9	33	4	10	38	4,200	5	5	33	.9	10	------	------	------
10	34	4	10	39	4,400	5	5	33	.8	10	------	------	------
11	35	4	11	41	4,600	6	5	34	.8	10	------	------	------
11	37	3	11	43	4,800	6	6	34	.7	10	------	------	------
12	38	3	12	45	5,000	7	6	34	.7	9	------	------	------
13	40	3	13	47	5,200	7	6	34	.7	9	------	------	------
14	41	3	14	49	5,400	7	6	35	.7	9	------	------	------
15	42	3	15	52	5,600	8	7	35	.7	9	------	------	------
16	43	3	16	55	5,800	8	7	35	.6	9	------	------	------
17	44	3	18	58	6,000	9	8	36	.6	8	------	------	------
18	44	2	19	61	6,200	9	8	36	.6	8	------	------	------
19	45	2	20	64	6,400	9	8	36	.6	8	------	------	------
20	45	2	21	67	6,600	10	8	37	.6	8	------	------	------
21	46	2	23	70	6,800	11	9	37	.6	8	------	------	------
22	47	2	24	73	7,000	12	9	37	.5	8	------	------	------

TABLE NO. 4.—GUN COMMANDER'S TABLE.

8-inch B. L. R.

I. V., 1,950 foot-seconds. Weight of projectile, 300 pounds. Jump, 6 minutes [using sight].

This table can be conveniently placed on the sides of a square cross-section stick. Using four sides, a stick 2 feet long allows 8 feet for graduation.

Range.	Elevation.		Time.
Yards.	°	'	*Sec.*
994	0	40	$1\frac{4}{8}$
1,035		42	$1\frac{4}{8}$
1,076		44	$1\frac{4}{8}$
1,116		46	$1\frac{5}{8}$
1,157		48	$1\frac{5}{8}$
1,198		50	2
1,239		52	2
1,280		54	2
1,320		56	$2\frac{1}{8}$
1,360		58	$2\frac{1}{8}$
1,400	1	00	$2\frac{2}{8}$

TABLE NO. 5.—GUN COMMANDER'S TABLE.

8-inch B. L. R.

I. V., 1,950 foot-seconds. Weight of projectile, 300 pounds. Height, 140 feet. Jump, 6 minutes [using quadrant].

This table can be conveniently placed on the sides of a square cross-section stick. Using four sides, a stick 2 feet long allows 8 feet for graduation.

Range.	Elevation.		Time.
Yards.	°	′	*Sec.*
994	−2	1	$1\frac{4}{6}$
1,035	−1	53	$1\frac{4}{6}$
1,076	−1	45	$1\frac{4}{6}$
1,116	−1	38	$1\frac{5}{6}$
1,157	−1	31	$1\frac{5}{6}$
1,198	−1	24	2
1,239	−1	17	2
1,280	−1	11	2
1,320	−1	5	$2\frac{1}{6}$
1,360	−1	00	$2\frac{1}{6}$
1,400	−0	55	$2\frac{2}{6}$

ESTIMATION OF HITS.

The point aimed at may be indicated by its range and azimuth. Preferably a material target will be used, the center of the water line of which is considered to coincide with the center of the imaginary ship, *i. e.*, the point where the intersection of two vertical planes containing respectively the central lines of beam and length pierces the plane of the water level.

The imaginary ship is supposed to be: (1) Broadside on to the battery; (2) End on to the battery.

The permissible errors, short, beyond, and lateral, taking into consideration the height of the battery, the angle of fall, and the dimensions of the imaginary ship, are calculated and tabulated.

The following table is given as an example, the site of the battery being on a level with the target:

BATTERY ADAMS.

Height, 0 feet. 10-inch B. L. R. Practise charge. M. V. 1,725 foot-seconds.

Range.	Slope of fall.		Permissible error for a hit.				Depression of target for 10 feet height.	Remarks.
			Broadside on.		End on.			
	1 on—	On 1.	Short.	Beyond.	Short.	Beyond.		
Yards.			*Yards.*	*Yards.*	*Yards.*	*Yards.*		
5,000	7.7	0.1299	31	51	79	99	0.00067	**Target imagined to be a ship of war 360 feet long, 72 feet beam, and 15 feet freeboard. Permissible error in direction, all ranges: broadside on, 60 yards; end on, 12 yards.**
5,100	7.5	.1334	31	50	79	98	.00065	
5,200	7.3	.1370	30	49	78	97	.00064	
5,300	7.1	.1408	30	48	78	96	.00063	
5,400	6.9	.1449	29	47	77	95	.00062	
5,500	6.7	.1493	29	46	77	94	.00061	
5,600	6.5	.1538	28	45	76	93	.00060	
5,700	6.4	.1563	28	44	76	92	.00058	
5,800	6.2	.1613	28	43	76	91	.00057	
5,900	6.0	.1666	27	42	75	90	.00056	
6,000	5.9	.1695	27	42	75	90	.00055	
6,100	5.7	.1754	26	41	74	89	.00055	
6,200	5.6	.1786	26	40	74	88	.00054	
6,300	5.5	.1818	26	40	74	88	.00053	
6,400	5.3	.1887	25	39	73	87	.00052	
6,500	5.2	.1923	25	38	73	86	.00051	
6,600	5.1	.1961	25	38	73	86	.00051	
6,700	4.9	.2041	24	37	72	85	.00050	
6,800	4.8	.2083	24	36	72	84	.00049	
6,900	4.7	.2128	24	36	72	84	.00048	
7,000	4.6	.2174	24	35	72	83	.00048	
7,100	4.5	.2222	23	35	71	83	.00047	
7,200	4.4	.2273	23	34	71	82	.00046	
7,300	4.3	.2326	23	34	71	82	.00046	
7,400	4.2	.2381	23	33	71	81	.00045	
7,500	*4.1*	*.2439*	22	33	70	81	.00045	

Every projectile which would have hit the imaginary ship, in either of the two positions, is entered in a table prepared for this purpose, and the total hits, so recorded, divided by 2. This gives the number of hits which would have been made on the ship, supposing her on the average during the period of the practise to have been midway between broadside and end on to the battery. This may be taken as a fair representation of what might be supposed to actually happen in action. The number of hits thus arrived at, compared with the number of rounds fired, gives a "percentage of hits" by means of which we can readily judge the comparative effect of the shooting.

The following table is given as an example:

CLIFTON BATTERY.

[a] *Record of counting hits, Battery "——," ——— U. S. Artillery.*

10-inch B. L. R.

Target, [b]——— ——— ———.

———, 189—.

Number of round.	By position finder.	By range party.		Error in direction.		Hits.		Hits to count.
	Range of target.	Short.	Beyond.	R.	L.	Broadside.	End on.	
	Yards.	*Yards.*	*Yards.*	*Yards.*	*Yards.*			
1	5,000	50		20				
2	5,050		24	6		1	1	1
3	5,150	10		7		1	1	1
4	5,275		5	38		1		½
5	6,020		10		25	1		½
6	6,030	42		4			1	½
7	6,050		9		2	1	1	1
8	6,075	29		8			1	½
9	6,075		4		2	1	1	1
10	6,080	19			5		1	½
Total						6	7	6½

Total hits, 6½; percentage, 65.

[a] See Plates—Page XX.

[b] Battle ship. Torpedo boat destroyer. Torpedo boat.

——————— ———————,

——————— *U. S. Artillery, Commanding Battery.*

APPENDIX.

RANGE TABLES.

8-INCH, 10-INCH, AND 12-INCH B. L. R.

The *General Table* (Table No. 1) is calculated for every thousand yards, and is intended to furnish the necessary data for constructing the battery commander's and gun commander's tables.

The method used in calculating it is explained by the accompanying example; the altitude factor is the same for the different guns and charges for the same time of flight—a fact which simplifies the calculations for *C*.

The *Battery Commander's Table* (Table No. 3) is intended to furnish the battery commander with the necessary data for making his corrections and predictions; range corrections are given in yards, and azimuth or deflection corrections in minutes, the data from the general table being converted to the required denomination (yards or minutes) and plotted on cross-section paper.

The *Gun Commander's Range Scale* (Table No. 4) gives *ranges* (every 10 yards), *elevations* (every 2 minutes), both *sight* and *quadrant*, and *times of flight* (every sixth of a second).

This range-scale is on a strip of muslin printed as cross-section paper, 10 by 10 to the inch, 3 inches wide and about 95 inches long, and the strip is placed on drums fitted in a box with a glass-covered opening in the top, through which any portion of the scale can be seen as it is wound up on one drum or the other by means of cranks placed on the drum axles. Table 4 shows the top of the box and the portion of the scale visible through the opening.

Two of these scales are provided for each gun; one for the *practise* charge, the other for the *service* charge.

These scales are platted from the data furnished by the general table for the gun and by Table 5. The following is a brief description of the operation:

Suppose the gun to be a 10-inch B. L. R., at 105 feet elevation above mean low tide. The quadrant elevation for each thousand yards of range, for that height, will be equal to the angle of departure in the general table for the gun diminished by the angle of depression; the latter angle being equal, in the example, to the angle in Table 5 opposite that range in the column headed 100 feet and the difference for 1 foot at that range multiplied by 5.

With these coordinates (range and quadrant angle) plat the points on a sheet of cross-section paper 10 by 10 to the inch, the horizontal scale being taken as 200 yards to the inch, and the vertical scale as 10 minutes to the inch, and draw the curve of elevations through the points thus platted. The ranges corresponding to every 10 minutes of elevation can then be determined and each 10 minute point entered in Table 4, opposite the proper range. By dividing the distances between the 10 minute marks into 5 equal parts, the quadrant elevation corresponding to any range sent by the *battery commander* can be quickly ascertained.

In a similar way the *sight elevations* and *times of flight* are obtained and entered in the table.

These scales should be made for the guns of a battery primarily from the *general table* and *Table* 5; but should be carefully corrected, if necessary, from the data obtained when the guns are *adjusted* and *ranged* with respect to each other for *uniformity of fire.*

A calculated range table is not final—it must be verified by, or be made to conform to, actual firing. A change should not, however, be made unless supported by reliable and sufficient data.

[*Example.*]

12-in. B. L. R. 2,025 f. s. 1,000 lbs.

$X=24{,}000$ ft. $Z=3{,}042.8$

$V'=2{,}000$ f. s. $A'=.03867$

$\log C=0.8969309$

$\log A'=8.5224442$

$\log \sin 2\phi'=9.4193751$

$\therefore 2\phi'=15^\circ\ 13'\ 38''$

$\frac{2\phi'+2\phi''}{4}=7^\circ\ 25'\ 48''$

$V''=2{,}050$ f. s. $A''=.03173$

$\log C=0.8969309$

$\log A''=8.5014701$

$\log \sin 2\phi''=9.3984010$

$\therefore 2\phi''=14^\circ\ 29'\ 35''$

$\frac{2\phi'-2\phi''}{2}=\Delta\,\phi\,(50\text{ f. s.})=22'\ 1''$

$C_1=.95\ C.$

$Z_1=3{,}203.\ \therefore A_1=.03485$

$\log C_1=0.8746545$

$\log A_1=8.5422028$

$\log \sin 2\phi_1=9.4193751$

$\therefore 2\phi_1=15^\circ\ 8'\ 13''$

$\frac{2\phi_1+2\phi_2}{4}=7^\circ\ 26'\ 53''$

$\frac{2\phi'+2\phi''}{4}=7^\circ\ 25'\ 48''$

$\frac{14^\circ\ 52'\ 41''}{2}=\phi=7^\circ\ 26'\ 20''$

$V=2{,}025$ f. s.

$C_2=1.05\ C.$

$Z_2=2{,}898.\ \therefore A_2=.03055$

$\log C_2=0.9181202$

$\log A_2=8.4850112$

$\log \sin 2\phi_2=9.4031314$

$\therefore 2\phi_2=14^\circ\ 39'\ 20''$

$\frac{2\phi_1-2\phi_2}{2}=\Delta\,\phi\,(.1\,\mathrm{C})=14'\ 26''$

$V=2{,}025.$ $Z=3{,}042.8.$ $\therefore B'=1.3321$

$\log \tan \phi=9.1153100$

$\log B'=\ .1245368$

$\log \tan \omega=9.2398468$ $\therefore \omega=9^\circ\ 51'\ 18''$

$V=2{,}025.$ $Z=3{,}042.8.$ $\therefore u=1{,}314.18$

$\log u=3.1138597$

$\log \cos \phi=9.9963380$

a. c. $\log \cos \omega=\ .0064562$

$\log v=3.1216539$ $\therefore v=1{,}323.3$

$$V=2{,}025. \quad Z=3{,}042.8. \quad \therefore T'=1.8809$$

$$\begin{array}{rl} \log C= & .8969309 \\ \log T'= & .2743657 \\ a.\ c.\ \log\cos\phi= & .0036620 \\ \hline \log T= & 1.1749586 \qquad \therefore T=14.96 \end{array}$$

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*$\Delta X=\dfrac{100\ Ws\ T}{X}\left(.01\dfrac{\delta_1}{\delta}\right)$ $Ws=$ velocity of wind; yds. per second.

$.01\dfrac{\delta_1}{\delta}$ expressed in yards.

$$\Delta X \text{ for 10-mile wind}=\frac{500\times 14.96}{8{,}000}\times 1.4\times 12.4=16.8 \text{ yds.}$$

$$1' \ \Delta\phi \text{ in yards}=\frac{100}{\phi(8{,}100)-\phi(8{,}000)}=\frac{100}{8+}=12.4$$

$$*\text{Drift}=\left(\frac{T}{3}\right)^2=\left(\frac{14.96}{3}\right)^2=25 \text{ yards.}$$

$$*\text{Deviation 10-mile wind}=\left(\frac{T}{3.3+\frac{R}{10{,}000}}\right)^2=\left(\frac{14.96}{4.1}\right)^2=13.4 \text{ yards.}$$

$$\log \text{penetration in steel}=\frac{10}{7}(7.681275-10+\log v)=\log e=1.14705$$

$$\therefore e=14.03 \text{ inches.}$$

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* Empirical formulas for 8-inch, 10-inch, and 12-inch B. L. R.

TABLE 3.—BATTERY COMMANDER'S TABLE—12-INCH B. L. R.

I. V., 2,025 f. s. Service charge, 490 lbs. Br. Pris. powder. Weight of projectile, 1,000 lbs.

Range corrections.						Deflection corrections.									50 per cent zone.		
$.01\frac{\delta_1}{\delta}$.	10 foot seconds I. V.	Tide 1 ft. dif. level.	10-mile wind.	Travel [during time of flight] 10 miles per hour.	Range.	Drift.	10-mile wind.	Travel [during time of flight] 10 miles per hour.	Value of one minute in yards of range.	Value of one yard in minutes of deflection.	Time of flight.	Angle of fall.	Slope of fall.	Penetration in steel.	Length.	Breadth.	Height.
Yds.	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Yds.*	*Min.*	*Min.*	*Min.*				° ′		*In.*	*Yds.*	*Yds.*	*Ft.*
.5	12.0	28.5	.4	7.7	1,000	1.1	.6	26.0	23.8	3.5	1.55	0 44	85.0	23.8	----	----	---
.6	13.7	24.5	.4	9.3	1,200	1.3	.7	26.4	23.4	3.0	1.87	0 53	69.0	----	----	----	---
.7	15.6	21.0	.5	11.0	1,400	1.5	.8	26.6	22.7	2.6	2.20	1 3	57.0	----	----	----	---
.8	17.2	18.0	.6	12.5	1,600	1.6	1.0	26.8	22.0	2.2	2.50	1 13	48.5	----	----	----	---
1.0	19.0	15.0	.8	14.1	1,800	1.8	1.1	27.0	21.6	2.0	2.82	1 23	44.0	----	----	----	---
1.2	20.5	13.0	1.0	15.7	2,000	2.0	1.3	27.2	21.0	1.8	3.14	1 34	38.0	22.0	----	----	---

TABLE NO. 4.—GUN COMMANDER'S RANGE SCALE.

(For 10-inch B. L. R., height 105 ft.)

	S. E.	Range.	Q. E.	Time.
PRACTISE.	28′	60		$11\frac{1}{8}$
		70	04′	
	6° 30′	80		
		90	06′	
	32′	5400		
		10	08′	
	34′	20		
		30	6° 10′	$11\frac{2}{8}$
	36′	40		
		50	12′	
	38′	60		
		70	14′	
	6° 40′	80		
		90	16′	$11\frac{3}{8}$
	42′	5500		
		10	18′	
	44′	20		
		30	6° 20′	
	46′	40		
		50	22′	$11\frac{4}{8}$
		60		
	48′	70	24′	
		80		
	6° 50′	90	26′	
		5600		
	52′	10	28′	
		20		$11\frac{5}{8}$
	54′	30	6° 30′	
		40		
	56′	50		

TABLE NO. 5.

For obtaining angles of depression for any height of gun above mean low water, at ranges from 1,000 to 14,000 yards for each 1,000 yards, corrected for curvature.

Range in yards.	Correction for refraction.	Angle of depression corrected for curvature.												Dif. for 1 ft.
		50 ft.			100 ft.			150 ft.			200 ft.			
	Secs.	°	′	″	°	′	″	°	′	″	°	′	″	′
1,000	2		57	30	1	54	48	2	52	00	3	49	05	1.144
2,000	4		29	08		57	47	1	26	25	1	55	03	.57277
3,000	6		19	50		38	56		58	02	1	17	07	.38188
4,000	9		15	19		29	38		43	57		58	19	.28644
5,000	11		12	42		24	09		35	37		47	04	.229108
6,000	13		11	02		20	34		30	08		39	40	.1911
7,000	15		9	55		18	06		26	17		34	28	.16366
8,000	18		9	08		16	18		23	28		30	37	.14322
9,000	20		8	35		14	57		21	19		27	41	.12733
10,000	22		8	12		13	56		19	39		25	23	.11455
11,000	24		7	55		13	08		18	20		23	33	.10422
12,000	27		7	44		12	30		17	17		22	04	.09555
13,000	29		7	37		12	01		16	26		20	50	.08811
14,000	31		7	33		11	39		15	44		19	50	.08188

The above table was computed by means of the following formula in Lee's Tables:

Correction for curvature, $\frac{D^2}{2R}$; or, the correction for curvature in feet is the number whose logarithm is ($\log D - 7.6209430$), D representing the distance in feet and R the mean radius of the earth.

MECHANICAL MANEUVERS.

The following instructions for mounting a 10-inch B. L. rifle on a disappearing carriage, together with a list of material required, is intended to serve simply as a general guide for such mechanical work. The same general method, with such modifications as the weight of the gun and carriage, and the nature of the ground necessitate, can be followed with other B. L. Rifles to be mounted on disappearing carriages

MATERIAL.

150 to 300 blocks, 12″ x 12″ x 44″.
20 to 50 blocks, 6″ x 12″ x 44″.
10 to 30 blocks, 4″ x 12″ x 44″.
20 to 30 blocks, 2″ x 12″ x 44″.
20 to 30 blocks, 1″ x 12″ x 44″.

25 blocks, 8″ x 8″ x 20″.
20 blocks, 4″ x 8″ x 20″.
20 blocks, 2″ x 8″ x 20″.
20 blocks, 1″ x 8″ x 20″.

6 skids, 12″ x 12″ x 22′.
10 skids, 12″ x 12″ x 14′.
10 skids, 8″ x 8″ x 14′.
20 skids, 8″ x 8″ x 6′.

15 rollers, 8″ x 9′, oak.
15 rollers, 6″ x 3′, oak.
20 way planks, 12″ x 3″ x 15′.
12 shifting planks, 12″ x 3″ x 15′.

1 gun cradle, 3 feet wide, 22 feet long.
4 thirty-ton hydraulic jacks.
1,800 feet hemp rope, 5-inch.
400 feet hemp rope, 7-inch.
4 trace ropes, 30 feet each.
1 garrison gin with double and triple sheave blocks, or
1 shears, or derrick.
2 treble, 2 double, and 3 single metal blocks for 5-inch rope.
1 capstan complete, with anchor stakes.
2 I beams, to support counterweight.
40 roller chocks.
6 gun chocks.
12 maneuvering handspikes.
2 crowbars, 6 feet long.
2 pinch bars, 5 feet long.
2 pinch bars, 7 feet long.
2 wrenches, slip, for 5-inch nuts.
2 wrenches, slip, for 3-inch nuts.
1 pipe wrench, large.
4 mauls, metal heads, with wood faces.
2 sledge hammers, 16 pounds.
1 marlin spike.
2 hammers, 4-pound, smiths'.
2 hammers, carpenters'.
1 crosscut saw, large, for timber.
1 handsaw.

1 hand ax.
1 hatchet.
1 mallet.
1 cold chisel.
1 straightedge.
1 steel tapeline.
1 plumb bob.
1 steel square.
1 2-foot rule.
1 carpenter's spirit level.
2 dog chains.
50 feet wire rope, 1½ inches diameter.
1 oil can, squirt.
10 gallons kerosene oil for cleaning.
2 gallons sperm or railroad oil.
10 pounds spun yarn.
50 pounds cotton waste.
10 quires emery paper.
1 quire sandpaper.
50 pounds 40*d*. spikes.
50 pounds 20*d*. spikes.
150 feet (board measure) plank, 2″ x 12″ x 12′.
50 feet (board measure) boards, 1″ x 12″ x 12′.
150 steel wedges, 4″ x 12″, ⅛ to ¼ inch thick, assorted.
2 counterweight hooks, steel, ¾-inch.
1 steel templet (caliper) for setting traversing circle.
White oak, 5″ x 12″ x 36″, for trunnion blocks.
Extra skids for use as cradles under base ring, chassis, etc.
Shovels, spades, picks, and mattocks.

All machined parts, including all joints, keys, bolts, bolt holes, and working parts, should be thoroughly cleaned with emery paper if necessary, and oiled with some good lubricating oil before being assembled.

In assembling, no parts of the carriage should be directly struck with a steel hammer; copper drifts, copper or lead hammers, being used.

When two bearing surfaces are brought together, it is especially necessary that both parts should be absolutely clean, smooth, and well lubricated.

The parts will ordinarily be put in position in the following order:

1. Base ring.
2. Racer.
3. Chassis.
*4. Top carriage.
5. Counterweights.
6. Gun levers.
7. Gun.

BASE RING.

First method.—Haul the cradle, with base ring on it, close to the interior crest of the parapet; raise it sufficiently high to run it on a crib work built to receive it; jack it down to the bottom of the pit. Raise the base ring with a garrison gin, remove the cradle, and lower ring to place, upon steel wedges, being careful not to burr the bolt threads. Level the ring, with the greatest care, by means of the steel wedges underneath and a sensitive machinist's level on the top surface of the pintle.

**If the top carriage is already in position*, as is usually the case, separate handling of it is unnecessary.

A grouting of neat Portland cement is then put under the base ring and allowed to set for 24 hours before any weight is put upon the ring.

Place rollers and distance ring in position.

Second method.—Erect a pair of shears, heels in rear of well, and firmly backed up with a skid and blocking against the rise of the lowest step of the loading platform. Haul the cradle, with base ring on it, close to the interior crest of the parapet, so that its center will be on a line bisecting the angle made by the backstays of the shears.

Sling one-half of the ring so as to hoist horizontally, being careful to prevent slipping of the slings, and also to prevent cutting on sharp edges of the casting by use of short wood carefully placed. Make fast hold-back to the middle of the half ring, if to the front; if not, use a bridle to the ends; take up all slack and make fast so as to slack off evenly and to retain control of weight when hoisted clear. Hoist away, and when clear, slack holdback gently until casting hangs plumb, and lower same as near as possible over its bolts, landing it on three stacks of full blocks, two high. Care should be taken to place this first half to the front or rear according to the holes drilled for the traverse stop bolts over the traverse rack. Lower other half in the same way; jack to joint and bolt firmly.

Place across any diameter of the ring a skid long enough to extend at least a foot beyond the ring on each side; sling the ring to this by chains passing over skids and under heavy bolts through drain holes.

Place thrust plates, which should be countersunk, and lower the ring over the platform bolts by jacking under the ends of the skids.

Level the ring with great care, using long steel rod and a delicate, accurately adjusted machinist's level, placing rod only on machined surfaces, and looking out for burred places and dirt.

When level, test the interior diameter at the pintle surface, as the ring is liable to become elliptical under strain of leveling.

The ring should now touch the concrete in at least one place. See that all the leveling screws are bearing; set up platform bolt nuts only enough to prevent the grout from leaking around them, and after the grout is set, screw them down as firmly as possible.

Place the rollers and the distance ring in position, and see that joint bolts are well set up, as the rigidity of this ring is important.

TRAVERSING CIRCLE. (MODEL 1894.)

The segments of the traversing circle may be placed on the cradle with the base ring and lowered with it. Each segment is then placed on two blocks (12" x 12" x 44") directly over its position, where it is assembled by screwing the joint plates firmly to place. It is then carefully lowered over its bolts, rested on steel wedges, using handspikes and pinch bars for the purpose, lowering one end and then the other, about a half inch at a time. The traversing circle is then carefully placed in position and leveled, using the machinist's level and the steel templet.

When leveled, it is bedded in the same manner as the base ring. The nuts are then put on the platform bilts, securing the base ring and the traverse circle in position, care being taken to avoid straining by taking up a little at a time on each nut.

RACER.

First method.—The racer, in sections, on a cradle, is lowered as prescribed for the base ring (First method), bolted together, and moved to its position over *the base ring.* The cradle is then removed, the racer lowered until the pintle surfaces are about one inch from engaging when the jacks are engaged with claws under the four projections which form part of seat of chassis; the racer is again lowered, keeping as nearly level as possible, until in position. Run the racer around to make sure that the rollers run freely, then put on the dust guards.

Second method.—Place three skids across the base ring parallel to the parapet. Sling half of racer and lower as prescribed for the base ring (Second method), resting bight of sling on the middle skid, and seeing that the other two skids are inside the joint flanges, and the end of the middle skid is blocked up outside the base ring. Lower the second half in the same manner, jack to joint and bolt firmly. Jack ring accurately over the pintle, jack up, remove skids and lower into position.

Run the racer around, to make sure that the rollers run freely, and then put on the dust guards.

If the clips have been shipped in place, they should be taken off before the ring is jacked over the pintle.

CHASSIS AND TOP CARRIAGE.

First method.—Figures 1 and 2, Plates, Page XIX, show the details of the blocking to receive the chassis and top carriage. *H*, *K*, and *L* represent the foundation blocking; *M* and *G* the two left piers of the carriage blocking; *N* and *O* the two left piers of the jack blocking. The skids *H*, *H'*, are first placed in position, the inner one 16 inches from the axis of the emplacement, its front end 2 feet from the upper surface of the traverse circle; upon them the rear piers of 12-inch blocks are erected. The skids *F*, *F'*, are next placed in position, care being taken that all four skids are level and securely blocked up under each end and middle. Upon these the front piers of 12-inch blocks for carriages and jacks are erected. The front and rear carriage piers, *M* and *G*, on each side are connected by two skids (12" x 12" x 22'), one on each side, and on the outside, replacing the corresponding 12-inch blocks on the inside. Upon the projecting ends of these, two skids *P*, *P'* (8" x 8" x 14'), are placed, and upon them, after the carriage is rolled on, the rear jack blocking *O* is built. The piers *M* are so placed that a 14-foot skid, *D*, will overlap it half way when its rear end is flush with the rear of pier *G*. *D* and *C* form the track upon which the carriage moves.

For a cradle, two 22-foot skids, *A*, are placed lengthways under the carriage; in rear, they pass between the two outer traverse wheels on each side; and in front, under a 14-foot skid, *B*, upon which that end of the carriage rests.

In lowering the carriage, the jacks are applied under the ends of the skids *A*, until the carriage approaches its bed, when a skid, *X* (12" x 12" x 14'), is placed under it.

Before placing the skid *X* in position, the top carriage should be moved as far to the rear as possible, and securely lashed in place.

Second method.—Place four skids (12" x 12" x 22') on racer, placing two close to joint flanges and the other two 2 feet outside of these. Build a pier crib of full blocks at each end of each pair of skids, commencing with cross blocks. When three blocks high, connect the four cribs with a stiffening deck consisting of eight skids (6" x 6" x 20') laid in pairs, perpendicular to interior crest, surmounted by eight more, about 10 feet long, laid across. These are so placed on each crib as to take the place of one full block.

Continue the cribs three and one-half blocks higher and put another stiffening deck as before. Proceed with the cribs until within 1 foot of the top of the parapet in front and 6 inches in rear.

Traverse racer, with handspikes, to the most handy position for pulling the chassis on to the crib, then pass on to the cribs two skids (12" x 12" x 22'), placing them as far apart as the cradle skids under the chassis; block in solidly between the forward cribs and the parapet, up to the level of the parapet, and lay way plank from the chassis to the rear of the skids, making the lap on the skids and not on the blocking in front of them. The crib should be well plumbed and leveled, and the blocks chocked, if necessary, with shingles, barrel staves, etc., to prevent any possible sway.

Jack up chassis and remove shipping cradle. Place two skids (12" x 12" x 22') lengthwise under the chassis, their outer sides resting against the counterweight guides in front and the elevating rack guides in rear.

On top of these place two strong cross skids (12" x 12" x 14'), the one in front close to the front edge of the counterweight guides and the other close to the front of the elevating rack guides, the ends projecting equally beyond the sides of the chassis. Haul the chassis on the crib, stopping it when the cross skids at the front of the carriage will barely clear the parapet. Build a crib of full blocks under each end of the two cross skids, putting two stiffening decks lengthwise on each side. Place a jack on each, under the cross skid and as near the chassis as practicable to save spring in the skids. Jack up and rest the chassis on the four jacking cribs; remove the cradle skids, the rollers, and the way planks, and block up between way skids and cross skids with small blocks. Jack up behind, and lower 6 inches; continue to lower, first in front, then in rear, to the horizontal, so that if the carriage slips at all it must be to the front, where the forward cross skid will catch against the parapet.

In lowering, the blocking under the way skids should be placed inside the cross skids to insure the way skids traveling properly.

Lower the carriage to position and bolt down.

COUNTERWEIGHTS.

Haul the disks on a cradle and unload them on blocking, or rollers, near the interior crest of the parapet. Set up the garrison gin with its head directly over the well, and its feet about 6 feet below the crest, on crib work built to support them, and lash the feet securely to the chassis. Build a suitable blocking with skids on top to receive the disks, which are run on rollers until directly over the well.

Place the two I beams on the racer across the well and near the cross-head guides, so as to be clear of the suspension-rod nuts.

Raise, with the gin, first the bottom plate (iron), remove the skids, lower the plate on the I beams, and carefully level it; then, in succession and in the same manner, lower each of the leaden disks.

Instead of I beams, the disks may be lowered on a blocking built up from the bottom of the well, the upper surface of the blocking being 5 feet 2 inches below the upper surface of the pintle.

If shears are used, the disks can be lifted directly from the parapet and then lowered, the head of the shears being so placed as to drop each disk in its proper position.

The disks should be slung by means of the two counterweight hooks and a good heavy chain.

The lower plate must be located with the greatest care. This may be done by placing a piece of scantling on top of the counterweight guides and from this suspending two plumb bobs, as far apart as the center of the holes in the plate, at equal distances from the guides, and in a plane one-half inch forward of the rear surfaces of the guides; pinch the plate until the plumb bobs are accurately centered in the holes.

Or, the center of the lower plate can be distinctly marked by fine cross-lines on its upper surface and this center brought in the same vertical line which contains the center of the pintle, by means of the straightedge and plumb bob. The level is then applied to the plate and any inaccuracy, however slight, corrected.

In lowering the leaden disks, great care must be taken not to move the lower plate, and each disk must be verified by plumb bobs.

After the counterweight is assembled, it should be tested by laying the straightedge accurately across the centers of the suspension-rod holes and applying the carpenter's square to the mark on the pintle surface, previously determined, to center the lower plate. If the vertical arm of the square just touches the straightedge at the point on it, previously marked, which corresponds with the outer surface of the pintle, the counterweight is in its proper position to receive the suspension rods.

GUN LEVERS.

First method.—Place the gun levers on skids for hauling and run them on a crib work built across the chassis sufficiently high to keep the suspension rods clear of the counterweight when swung down to a vertical position.

Worm the threads of these rods with wire or strong cord to prevent their being filled with lead while passing through the counterweight.

Lower the levers by two jacks, one at each end, working alternately 4 feet to 6 inches at a time. See that the suspension rods pass through the counterweight without binding, and that the cross-head clips engage the guides perfectly. Remove the cap squares and lower until the lever axles are in their beds. Screw the nuts and check nuts on the suspension rods and support the rear ends of the lever on blocks placed on the buffer brackets.

Second method.—Block the carriage so that it will not turn on rollers. Place two skids from parapet to top carriage, resting on the latter so as not to drop or work to the rear, and projecting not more than 6 inches above the interior crest. The gun levers should be on skids or on a cradle narrow enough to pass between the cheeks of the top carriage, and should be hauled in, trunnion bed first.

Make a line fast to a skid through the trunnion bed and take it to a capstan to haul ahead; attach a strong luff tackle, say a 5-inch line, by means of a chain, to the gun-lever axle for a holdback, taking the single block to a solid anchorage and catching a turn with the fall so as to ease off smoothly and retain control of the weight.

Put a heavy strap, 5 or 6 inch, around the skid through the trunnion bed, and attach the hoisting gear of the shears. The gun levers should leave the rollers at the crest and slide down the inclined skids.

Heave on the head line and slack the holdback gently. As soon as the fall leads inside the plane of the backstay of the shears, hoist a little so as to ease the lead along, and when the lead of the fall reaches the limit of the other back stay, shift the strap to the gun-lever axle. Keep moving in this manner until the axles are over the trunnions beds.

Remove the cap squares and the upper cap square bolts; if the latter can not be started, remove the bolts from the right rear piston rod bracket and the nuts from the forward ends of both piston rods; the top carriage can now be forced back far enough to clear the bolts.

Turn the counterweight bearers to the front and remove the nuts, being careful not to jam the threads, as they will rest temporarily on the parapet. Sling the levers at the center of gravity, about 18 inches forward of the trunnions, with four turns of a 5-inch line; attach block and hoist away until the levers are clear of everything.

The shears should be so trimmed, before hoisting, as to now suspend the levers nearly if not quite over their trunnion beds.

Turn the slide racks to the front and lower the levers, steering the counterweight bearers into the holes in the lead, and directing the trunnions into the trunnion beds. Replace the cap squares and run the carriage into battery, thus forcing the counterweight bearers down through the lead.

It may be necessary to put the fall on the upper end of the levers, and it will require much force unless the lead has been accurately placed.

The threads of the counterweight bearers should be wormed with wire or strong cord to prevent their being filled with lead.

Put on counterweight bearer nuts and fill recoil cylinders full; assemble traversing gear and elevating gear, being careful to mesh the pinions in the racks at the proper point; put on sighting platforms, sight, post, racer floor plates, and chain buckets (on earlier carriages).

The traversing stop bolts may be put in at any time after the base ring is set.

The piece when delivered at the battery should be placed on blocking at least 2 feet high, and never on the ground itself. Lay an 8-inch oak roller on top of the piece, about 3 feet from the face of the breech; pass a wire rope (50 feet of 1-inch wire rope) over the left end of the roller, down under the piece, up over the right end of the roller, down under the piece, up over the left end of the roller, repeat the whole operation again, and clamp the free ends together; the rope will thus pass four times under the piece and twice over each end of the roller. Jack under each end of roller, as close to the piece as possible, and when all the slack is taken up, fill in solidly between the roller and piece with small blocks.

The roller must be protected by placing between it and the wire rope several pieces of 2-inch stuff, and a 1-inch piece between heads of jacks and roller.

When the piece is sufficiently high, the track is built, the cradle and rollers (6 inches 3 feet) placed under it; the cradle should be so placed that the breech will project 14 inches beyond it.

The piece now rests on three blocks, and strong cleats are nailed on them to prevent the piece from rolling.

The blocking, in the emplacement, to receive the piece, consists of two single piers, one in front and one in rear, supplemented by a third placed on the top carriage. (See Plates, Page XIX.)

When the front pier is exactly 2 feet below the crest of the parapet, it is connected with the carriage blocking by two skids (12″ x 12″ x 14′), *A*, 3 feet apart measured from the outside; on these are placed two skids (12″ x 12″ x 22′), *B*, their rear ends flush with the rear face of back blocking. The space between the front ends of these skids and the parapet is filled with 12-inch blocks, *C*; on this four way planks *D*, *D′*, are placed, the front ones extending beyond the parapet so as to bring the junction, *G*, slightly in rear of the piece.

After the trunnions are directly over their beds, the blocking *E* is placed under the breech, the jack blocking built under the muzzle, and the latter raised so as to free the cradle. The blocking is built on either side of the muzzle, a skid run across to receive it, and the jack removed. The cradle is then run out to the front and the planks *D* removed. The piece being lowered by jacking under, the muzzle is supported on blocks on the parapet and on the skid *B* just in front of the point marked *G*; the planks *D* are now removed and the block *E* replaced by a 6-inch block; the muzzle is again raised, releasing the blocking at *G*, which in turn is lowered. This operation is continued until the trunnions rest in their beds, there being ample space between the skid *B* and the piece to accomplish this.

The rear studs of the gun lever should be removed before rolling out the piece.

ELEVATING BAND AND BREECH GEAR.

Attach retraction chains and adjust them to equal tension. Put a skid in the muzzle of the gun, projecting therefrom about 4 feet, and haul the gun from battery. Remove one side of the elevating arms, engage each side on its trunnions, and bolt together; remove the cap squares and upper half of journal boxes. Place a Piper gin, or similar appliance, in rear of and close to the breech; sling elevating band by its trunnions and hoist it to the height of the breech; attach the retraction chains to the trunnions and work the cranks. The chains should be of equal length and the band will be easily drawn along. As soon as the band is far enough on the gun, raise the elevating arms (the racks being run down) and engage the trunnions, replacing the journal boxes and cap squares. Shift the retraction chains to the elevating arms, remove the skid from the muzzle and go ahead on the cranks until the trunnions of the elevating band are 100 inches from the gun trunnions, center to center; measure both sides carefully and see that the trunnion axis is horizontal. Put emery cloth or sandpaper between the gun and band, wherever it will go in, and set up nuts hard.

Sling the breechblock, hoist it with the gin and insert; assemble the small parts.

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